JULY 6, 1959

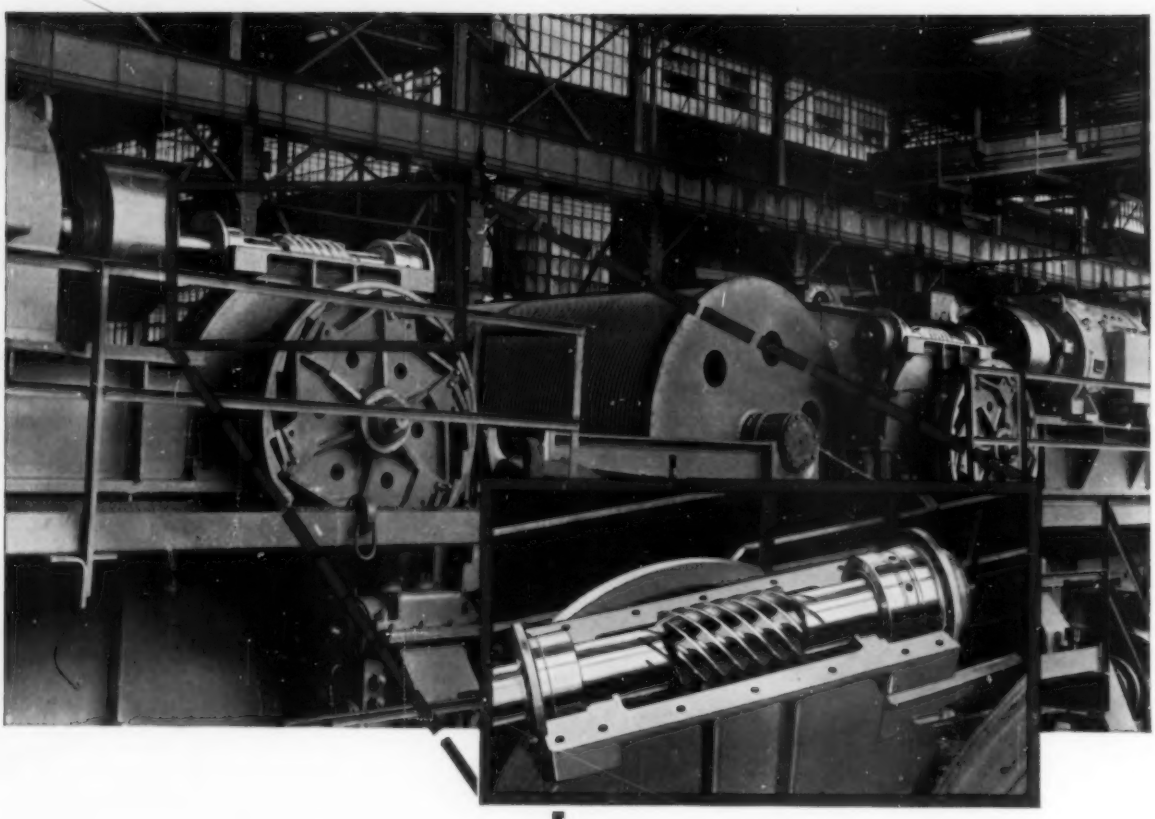
Product Engineering

DESIGN issue

McGRAW-HILL WEEKLY ... RESEARCH AND DEVE... ENT

FREEDOM IN DESIGN BUILDS STARS

... see page 5



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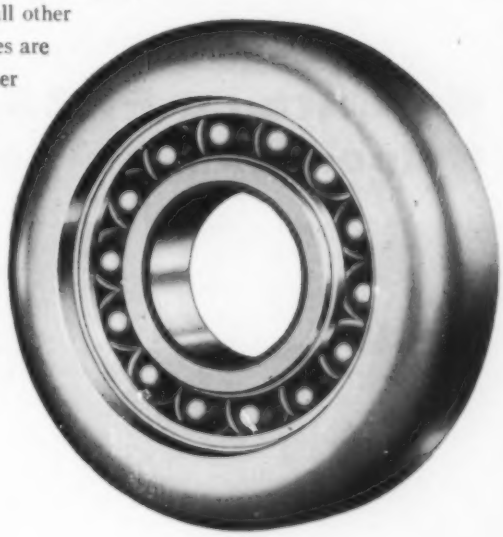

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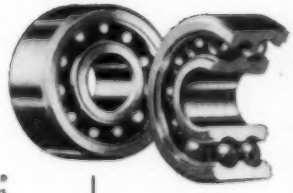
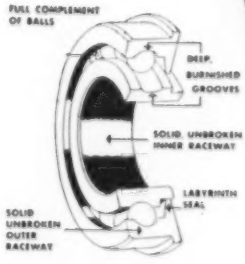
Bearings with plain outer members in small sizes.

. . Medium sizes or sizes to 2" diameter and over

Bearings with flanged outer members in all sizes



Double row type bearings.



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Manufactured by THE HEIM COMPANY
for Universal Bearing Corporation
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Retaining rings in a multitude of shapes and sizes are speeding assembly and cutting production costs of a host of industrial and consumer products. A leading manufacturer of these efficiency-improving parts recently greatly expanded the range of applications for retaining rings by adding a complete line of standard and special rings of Armco PH 15-7 Mo Stainless Steel.

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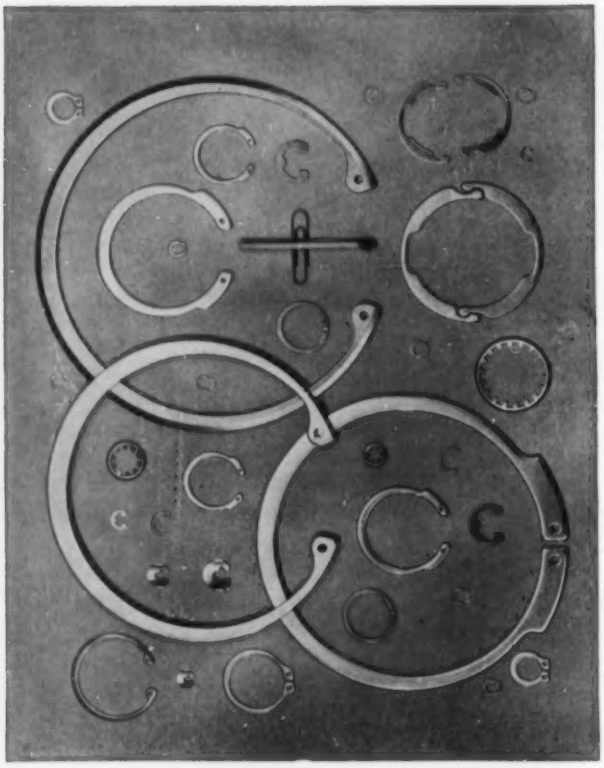

reactors, appliances; marine equipment; and other applications subject to severe service conditions.

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Product Engineering

McGRAW-HILL WEEKLY OF DESIGN, RESEARCH AND DEVELOPMENT

DESIGN issue

July 6, 1959 Vol. 30, No. 27

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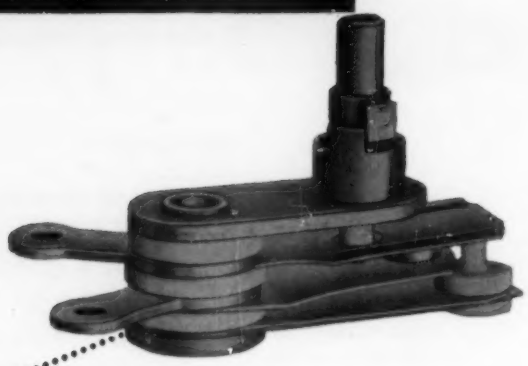
FOR SKILLETS, SAUCEPANS, GRIDDLES*



Type S above; Type H below. Other designs available.

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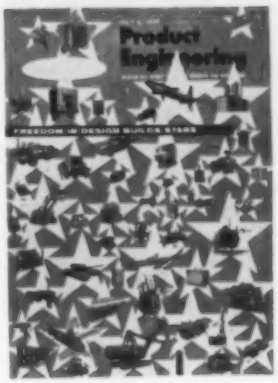
Interesting to Note . . .

Freedom of Design Builds Stars



With the 48 in our United States becoming 49, and with the 50th in the immediate offing, we felt that the idea would be particularly appropriate for an Independence Day cover. There will presumably be an eventual official arrangement, but as of now our polyglot arrangement of 50 stars of various sizes on a field of blue is as good as any.

It is also important at a time like this to realize that the strength of each of these stars depends upon the products you design, industrial as well as military. Further, the strength of all the stars combined is no greater than our combined ability to produce these designs.

We have selected the 50 products rather arbitrarily, but among them are certain to be some quite akin to yours. Undoubtedly, however, yours will function or look differently in general or in detail, which brings us to the point of the cover legend. In these United States, the designer has the freedom to design as he will, subject only to the wants of the buyer and the price he is willing to pay. Design is not regimented or forced into an arbitrary mold. This assures the designer the right to fail, to fall—or to build another star.

The cover was painted by Art Director Rooman, based on ideas from several editors, with the aid of an inexpensive Donald Duck watercolor set he bought for his youngest son. He exercised his artistic license to select star sizes and arrange them as he willed—now complains that the endless short brush strokes in so detailed a painting cost him the freedom of his right hand for a week or more after he finished.

The Forgotten Genius

One of the problems of our day is recognizing the truly gifted scientist in order to best make use of his capabilities. Unfortunately, it happens that some scientists and engineers make their mark, then pass into oblivion, unrecognized. Electrical pioneers like Henry, Edison, Bell and Westinghouse will long appear in the pages of scientific history books, and as busts in the Hall of Fame, but what about Nikola Tesla? This week marks the 103rd anniversary of his birth—an appropriate time to observe his contribution to science.

Yugoslav by birth, Tesla received his engineering training at the

(CONTINUED ON PAGE 7)

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Polytechnic School, Graz, Austria. It was there, too, that he received his first rebuke. His teacher in theoretical and experimental physics was demonstrating a Gramme dc dynamo. Tesla noticed sparking at the commutator and brushes and asked why not develop a motor that didn't require brushes. This was too much for his professors, who spent the rest of the class period embarrassing Tesla and showing why such a "perpetual motion machine" would be out of the question. Tesla still felt that a brushless motor was possible.

Then one day in 1882 a vision flashed across his mind; he clearly pictured an iron rotor rapidly spinning in an electric whirlwind—a rotating magnetic field produced by the interaction of two alternating currents out of step with each other. Six years later he patented this principle for an induction motor.

Meanwhile he was having the trouble described by his friend, Kenneth Swezey, in *Science* (May 16, '58). It seems that when Tesla arrived in the US in 1884, he had but four cents in his pocket. He soon got work with the Edison Machine Works for $18 a week plus the promise of $50,000 bonus when he completed the job of designing 24 dc dynamos. For a full year he worked 19 hours a day only to find that the promised bonus was all a joke.

Ac motors were of special interest to Tesla and with the help of private capital, he spent the next several years experimenting and working on his ac system. Although there is no record, almost assuredly Tesla observed the principle of braking a ninduction motor (p 60) by reversing the field. Eventually, electrical engineers here and abroad accepted what Tesla had tried to tell his physics teacher many years earlier. Edison was already lighting cities with his direct-current system, but transmission costs prevented those in the outskirts from benefiting. Westinghouse realized the problem and gathered a staff to study alternating current as a possible solution (*PE—Jan 27, p 5*).

The test came when Westinghouse won a contract to supply the electric power at the 1893 Chicago World's Fair. Because there were no large polyphase generators, Westinghouse built twelve 1000-hp two-phase generators, adopting Tesla's ac concept.

Plaster bust made after Tesla's death by sculptor Ivan Mestrovic. On exhibition at the Yugoslav Academy of Art.

Tesla died in 1943. Long before that he had dabbled with such things as a gas-filled, phosphor-coated bulb—50 years before fluorescent lighting, high-frequency currents, radio-controlled weapons, and even radar. It is shameful that Nikola Tesla has been forgotten so soon after his death and even more tragic that his mind and creative abilities were not adequately harnessed during his life. Fortunately, many engineering groups honored his 100th birthday three years ago, and recent reevaluations of his work in the light of today's technology have rightly increased his stature.

He Took the Sun's Measure

As is often the case, advances in one field of scientific endeavor directly benefit other groups. So it was in 1638, when a 20-year-old astronomer named William Gascoigne tried to measure the diameter of the sun. He devised a form of celestial triangulation which hinged on a very accurate measurement of the sun's image within his telescope. However, a graduated scale cut into the eyepiece was too crude—and a finer scale couldn't be read with the eye. A new means of measurement had to be conceived to do the job.

Gascoigne then developed a special type of caliper whose indicating fingers were moved simultaneously in opposite directions by a screw having a left-hand thread on one end and a right-hand screw on the other. According to Gascoigne's records, he could measure angles accurately to seconds by calibrating the rotation of the screw thread. Unfortunately, the Civil War of 1642 prevented the young astronomer from further scientific experiments. He was killed during its first day.

His principle of using a screw thread as a means of measuring gave impetus to the development of the micrometer. The modern micrometers of today (p 65) rely on this principle even though their operation requires nothing more than pushing a button and reading a counter.

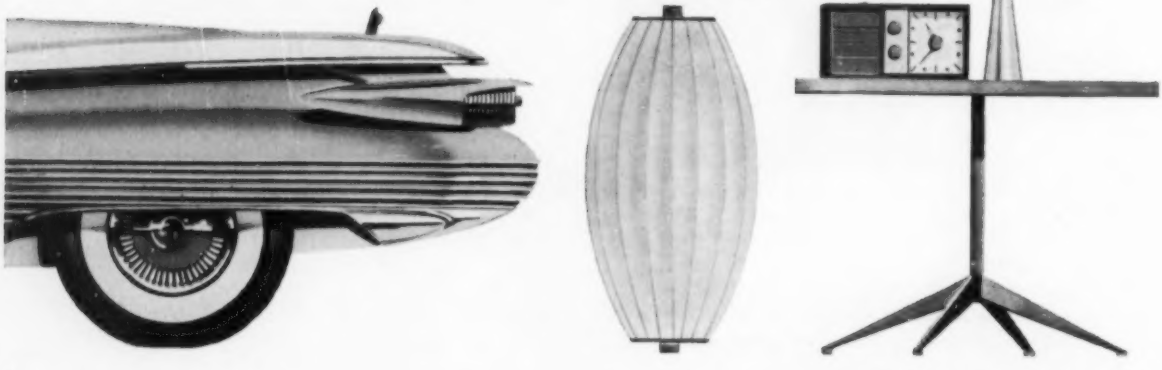
Boss Ket on Experiments

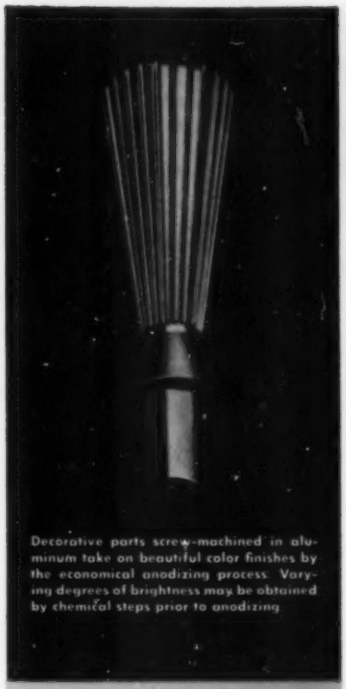
Many an old-timer will remember hearing C. F. (Boss) Kettering's five-minute intermission talks on science and invention given in connection with the General Motors Symphony of the Air. Every Sunday from September 1942 to July 1945, "Boss Ket" would spin a folksy yarn that usually hammered home the importance of research. He believed "there will always be a frontier where there is an open mind and a willing hand." He told his radio audience that experiments (p 66), whether conducted on a million-dollar scale by GM or in the basement of a lone-wolf inventor, must be a search for facts, knowing that "an ounce of experimentation is worth a pound of untried theory." Kettering long believed in the necessity of maintaining a heavy R & D program. He wanted GM to learn by experiment rather than rely solely on the printed page.

He once told a story of the college professor who spoke to his class before graduation: "I have given you the best information available—the best case histories I could find. The textbooks we have used are the most widely accepted and reliable. But before we part company, I want to caution you that science is developing so rapidly that in a few years from now perhaps half of the things I have taught you won't be so. Unfortunately, I don't know which half that will be." —**Benedict A Leerburger Jr**

What the designer conceives...aluminum achieves

COLOR BEAUTY NATURAL BEAUTY





Decorative parts screw-machined in aluminum take on beautiful color finishes by the economical anodizing process. Varying degrees of brightness may be obtained by chemical steps prior to anodizing.

Clear-anodizing produces a jewel-hard coating that protects aluminum's natural silvery beauty—and at far less finishing cost than other processes such as plating or polishing.

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COST DATA FOR 1000 PIECES*

	Aluminum		Brass
Material (53 lbs.)	$28.20	(159 lbs.)	$52.86
Less 47% scrap (@ 16.5¢/lb.)	4.13	(@ 18¢/lb.)	13.50
Total Material Costs	$24.07		$39.16
Machining	11.00		11.00
Approximate Tooling Costs ($190)	1.90		1.90
Color Anodizing	10.00		
Total Cost	$47.77		$52.86

Total Savings per 1000 pieces $ 5.09 (In Aluminum)

(An unlimited number of metal bonded colors are available with aluminum—obtainable in other metals only by less durable surface coatings.)

COST DATA FOR 1000 PIECES*

	Aluminum		Brass
Material (73 lbs.)	$37.74	(218 lbs.)	$66.05
Less 52% scrap (@ 16.5¢/lb.)	6.27	(@ 18¢/lb.)	20.34
Total Material Costs	$31.47		$45.71
Machining	25.65		25.65
Approximate Tooling Costs ($200)	2.00		2.00
Clear Anodizing	10.00		
Chrome Plating			15.00
Total Cost	$69.12		$88.36

Total Savings per 1000 pieces $19.24 (In Aluminum)

*(These are estimated costs based on runs of 100,000 pieces)

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Series 6800, 6900, 7800, 7900 roller bearing pillow blocks have spherical roller bearings with internationally standardized boundary dimensions.

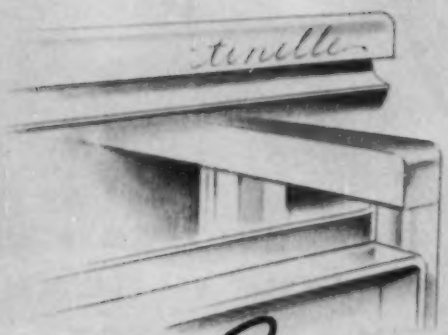
LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15,181-A

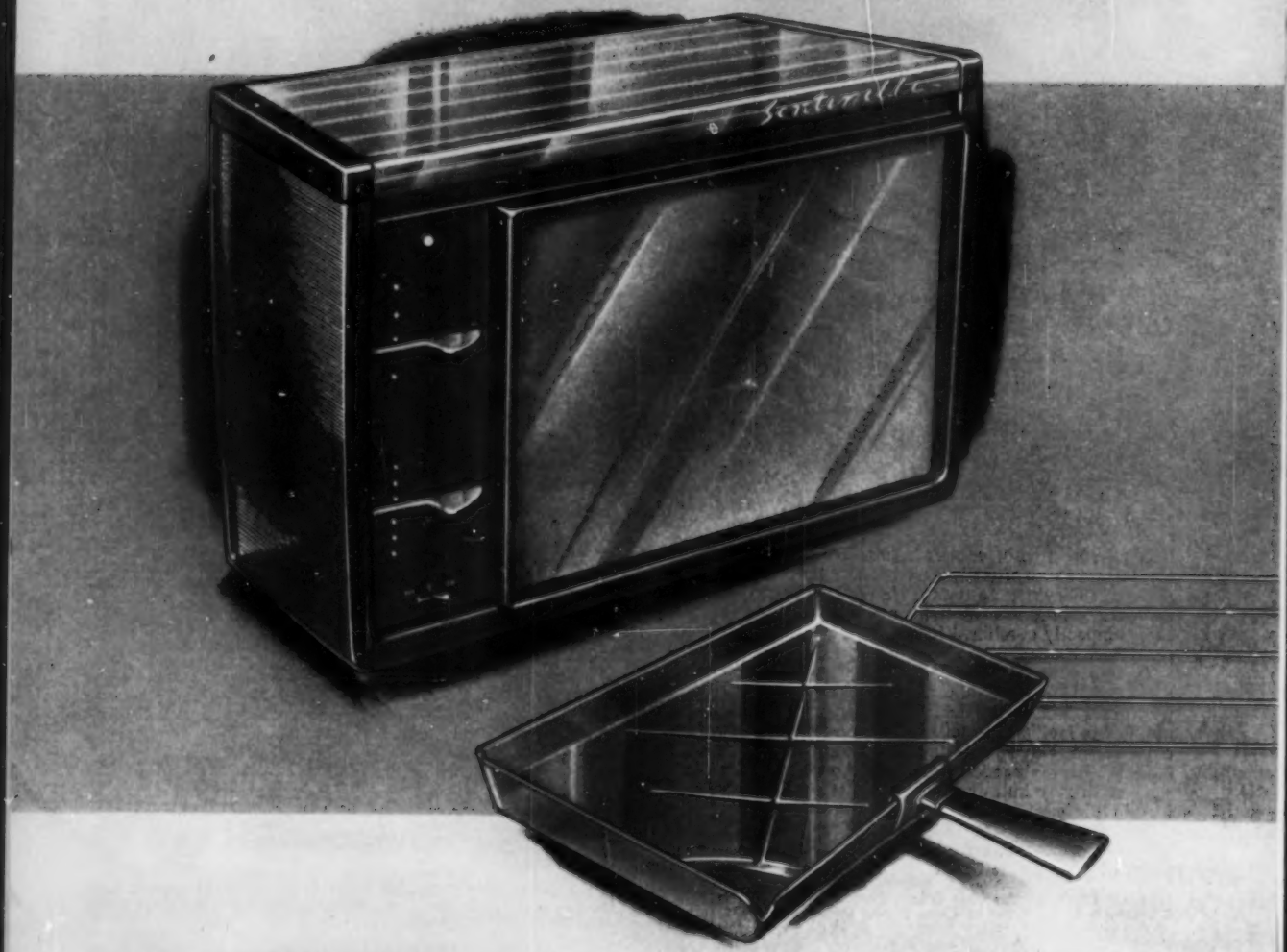
CIRCLE NO. 11 READER SERVICE CARD

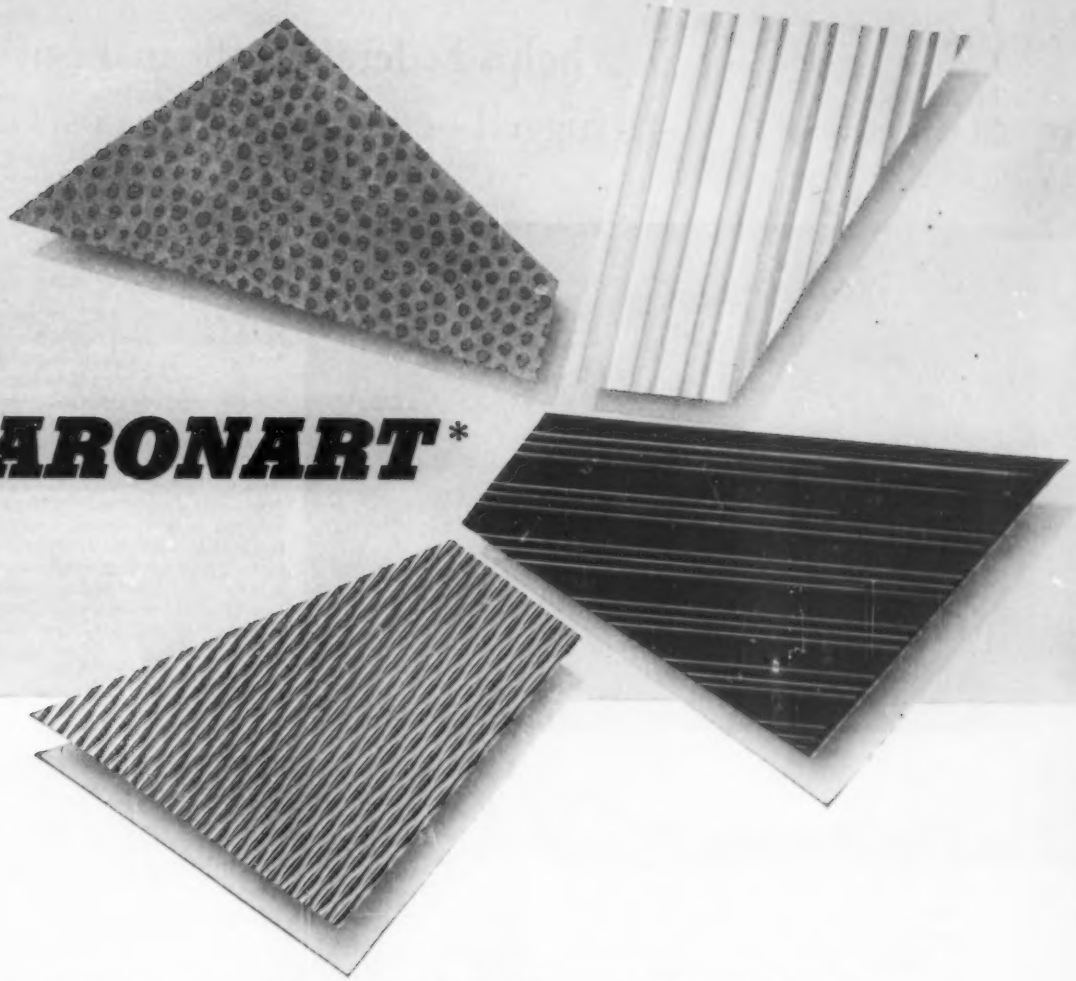
CIRCLE NO. 12 READER SERVICE CARD



One of America's best known and most successful designers, Russel Wright, is practically a household word to Mrs. America. He, more than any other one man, has brought practical design to the average American housewife. Mr. Wright believes "good design" should be universal and his general aim is to create the widest variety of products for the widest possible market at the lowest possible cost so that "good design" can reach everyone.

Russel Wright designs with..





....SHARONART*

The portable broiler is high on the list of appliances most wanted by the modern American housewife. Until recently, little attention was paid to its design. The unwieldy bulk and lackluster styling of most models contrasted with the functional beauty of today's colorful kitchens and kitchen tools.

Russel Wright, world famed designer, has applied his talents to this appliance and has created a broiler with the attractive tailored look designed to harmonize with modern day kitchens.

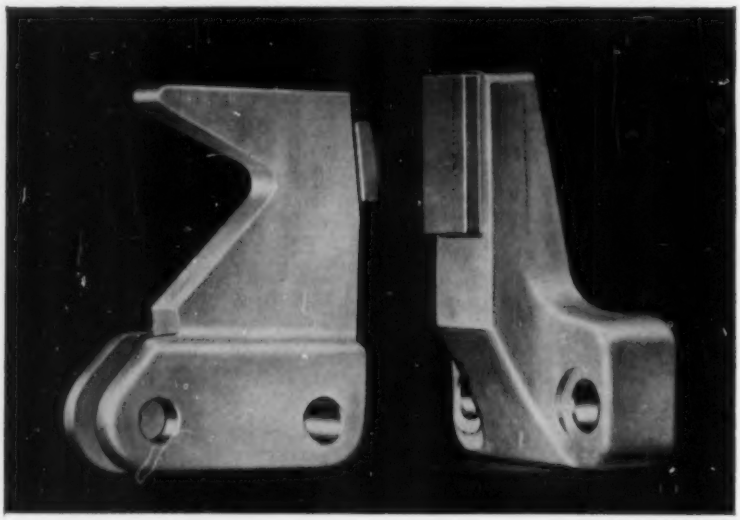
In place of the outmoded polished chromium cover, Mr. Wright has utilized Sharon Steel's exciting new Sharonart* stainless in combination with a main shell of colored baked enamel over textured Sharonart*. Russel Wright has replaced impractical broiler operation with simple, functional, press-down levers that automatically set the thermostat and timer, and has included a stainless steel well-and-tree tray designed to be carried to the dining table and generous bakelite handles for safe carrying of the unit.

Whether you make broilers—or any other appliance—it's certain Sharonart* will give your product the same fresh look Russel Wright has achieved in this broiler design. *The Sharon Steel Corporation, Sharon, Pa.*

SHARONSTEEL **SHARON** *Quality* **STEEL**

TWICE-WROUGHT METAL

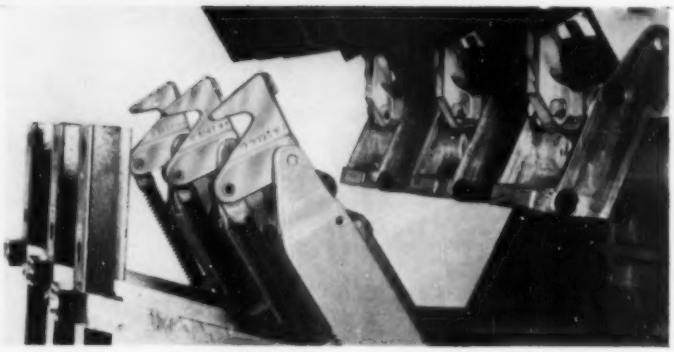
of die-pressed forgings helps Federal Pacific make new air circuit breakers more rugged—cuts machining costs in half

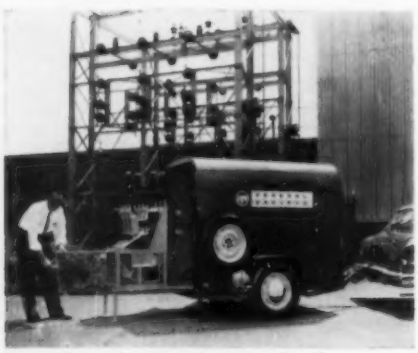


In its new Type DST magnetic air circuit breaker line, Federal Pacific Electric Company, Newark, N. J., builds in dependable operation and long life with parts of outstanding mechanical and adequate electrical properties.

Typical of this attention to detail are the arcing contacts (left). Similar parts previously used had been castings or built-up assemblies. Now the contact bodies are Anaconda Forging Brass-250 die-pressed forgings. The twice-wrought metal is denser, stronger, withstands mechanical shock better—reducing the fatigue factor and producing longer service life. The contacts also have higher conductivity. And best of all, their consistent dimensional accuracy and smooth finish cut machining costs in half.

RIGHT: Movable arcing contact assemblies at the left and the stationary arcing contact assemblies at the right in a 5-kv Federal Pacific Type DST air circuit breaker. They have a momentary current-carrying capacity of 60,000 amperes. Contact tips of tungsten alloy are silver-soldered to the forgings. These are two of several areas where Federal Pacific uses the superior physical properties of Anaconda die-pressed forgings to help provide dependable operation and long service life in its line of metal-clad switchgear.





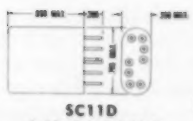
Federal Pacific takes its circuit breakers out to industrial and electric utility customers. Here a representative sets up a demonstration of a 5-kv, 1,200-amp breaker in the field.

IT IS often easier than you think to achieve high quality and performance while simplifying fabrication and cutting over-all costs. American Brass technical specialists are constantly working with designers, production engineers and buyers, helping them meet their joint requirements—through the use of such Anaconda mill products as die-pressed forgings, extruded shapes, special-shape tubes. For this kind of practical help, see your American Brass representative or write: The American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Toronto 14, Ontario. 8944

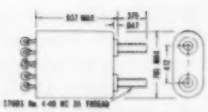
ANACONDA®

COPPER • BRASS • BRONZE
NICKEL SILVER • MILL PRODUCTS

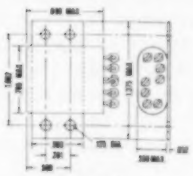
Made by The American Brass Company



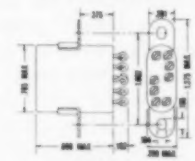
SC11D
6, 12, 24, 36 Volts



SC11DK
6, 12, 24, 36 Volts



SC11DB
6, 12, 24, 36 Volts

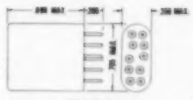


SC11DA
6, 12, 24, 36 Volts

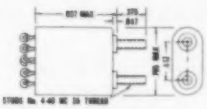
SC

2 TYPES • 4 MOUNTINGS • 4 VOLTAGES

SL



SL11D
6, 12, 24, 36 Volts



SL11DK
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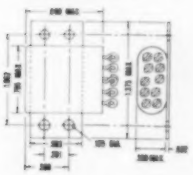

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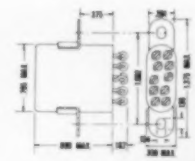
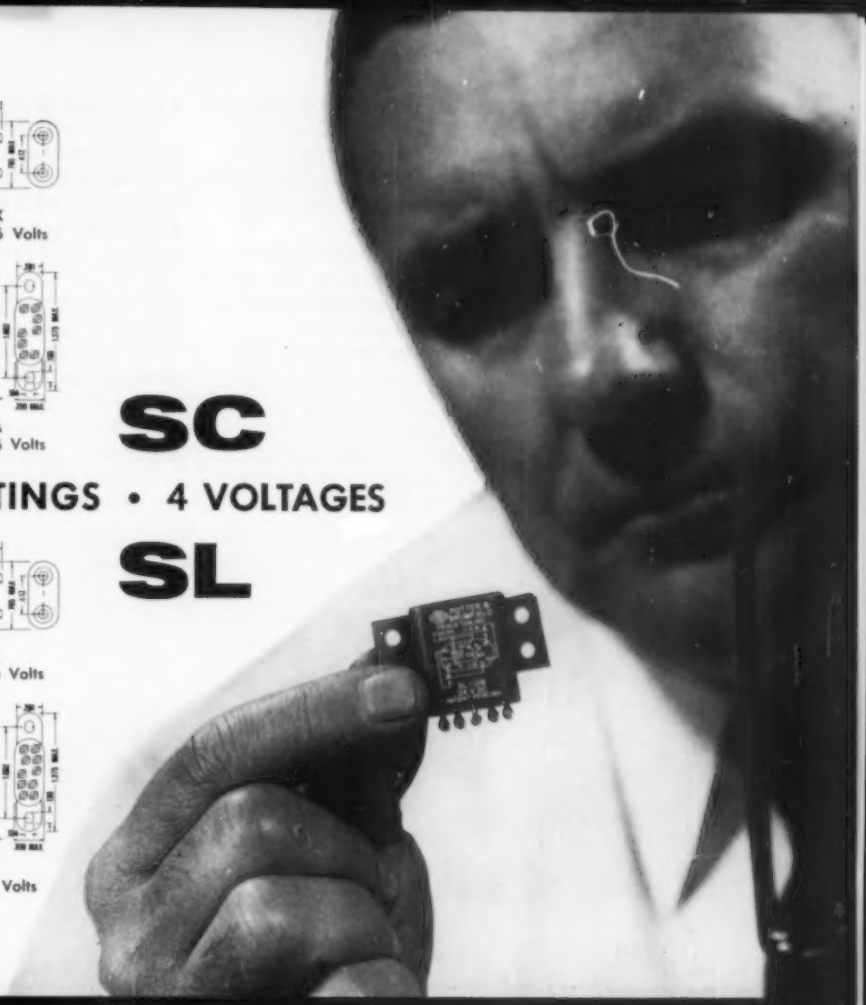


SL11DA
6, 12, 24, 36 Volts



Off the shelf delivery FROM YOUR P&B DISTRIBUTOR

32 STANDARD P&B CRYSTAL CASE RELAYS

Prototype or small-production-run quantities of P&B's micro-miniature relays are now available from your local electronic parts distributor. Choose from 2 types, 4 mountings, 4 coil voltages—32 models in all.

P&B's dual coil, permanent magnet, crystal case relays remain operative under 100g shock, 30g to 2000 cps vibration. Modern White Room production facilities assure highest possible reliability.

The SC conforms to standard dimensions and circuitry, and can replace ordinary relays of the same size.

The SL, a latching relay, utilizes the dual-coil, permanent magnet principle to provide a highly efficient, tenacious latch, assuring high contact pressure.

Order today from your local electronics parts distributor.

SC and SL SPECIFICATIONS:

Shock: 100g for 11 millisec.

Vibration: 30g from 55 to 2000 cps
.195" max. excursions from 10 to 55 cps

Ambient Temperature Range:
—65°C. to +125°C.

Contact Arrangement: dpdt

Contact Load: 2 amps at 30 vdc
1 amp at 115 vac, 60 cycle

Sensitivity:
SL—230 milliwatts at 25°C. with 630 ohm coil
SC—260 milliwatts at 25°C. with 550 ohm coil

POTTER & BRUMFIELD

DIVISION OF AMERICAN MACHINE & FOUNDRY COMPANY, PRINCETON, INDIANA

IN CANADA: POTTER & BRUMFIELD CANADA LTD., GUELPH, ONTARIO

CIRCLE NO. 15 READER SERVICE CARD

Failure of any part of a missile—be it the mighty Atlas, Jupiter or Thor—can mean failure of the mission. That's why the complex connections in the ducting systems of these and other missiles are silver brazed. These connections must stand up under 6,000 psi; they are tested to 12,000 psi.

In lines made to specifications by Flexonics Corporation, Maywood, Illinois, silver brazing joins a corrugated flexible pressure carrier, a braid sleeve and a coupling nipple—all of stainless steel; it permits joining all of these elements of the assembly without danger of annealing the pressure-carrying flex or the restraining braid as welding might do.

Assemblies designed for 6,000 psi operating pressure are required to withstand a 12,000 psi test and take four times their normal operating pressure before failure. They may also be required to pass a flame test in order to meet specifications.

The silver-brazed connections are used on hydraulic and pneumatic systems, fuel drain lines and vent tubes. Some of these applications involve rigorous service with extreme pressure shocks accompanied by sudden elevations of temperature, which may go from −60° to 400-600° F in a matter of seconds.

A more "high level" endorsement of Handy & Harman silver alloy brazing is not available. On the ground or in the air, the qualities of this remarkable metal joining method apply; strength, ease of production, cost, gas and liquid joint tightness to name a few. The entire brazing story is yours merely for the asking. Inquiries and metals-joining "problem exposure" may be addressed to Handy & Harman, 82 Fulton Street, New York 38, N. Y. We welcome the opportunity to work with you.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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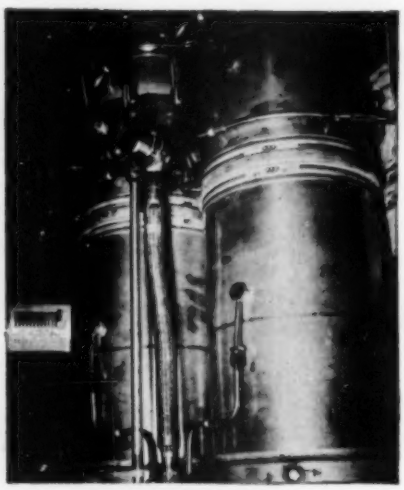
No Margin Here for joint failure!

Assemblies in ATLAS Missile **HANDY & HARMAN** Silver Brazed

Intercontinental Atlas missile being made ready for launching.



Close-ups of missile section, showing silver alloy brazed ducting assembly.

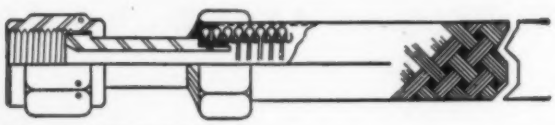


Diagram of pressure carrier.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

How steel tubing saves weight in helicopter...in budget, too

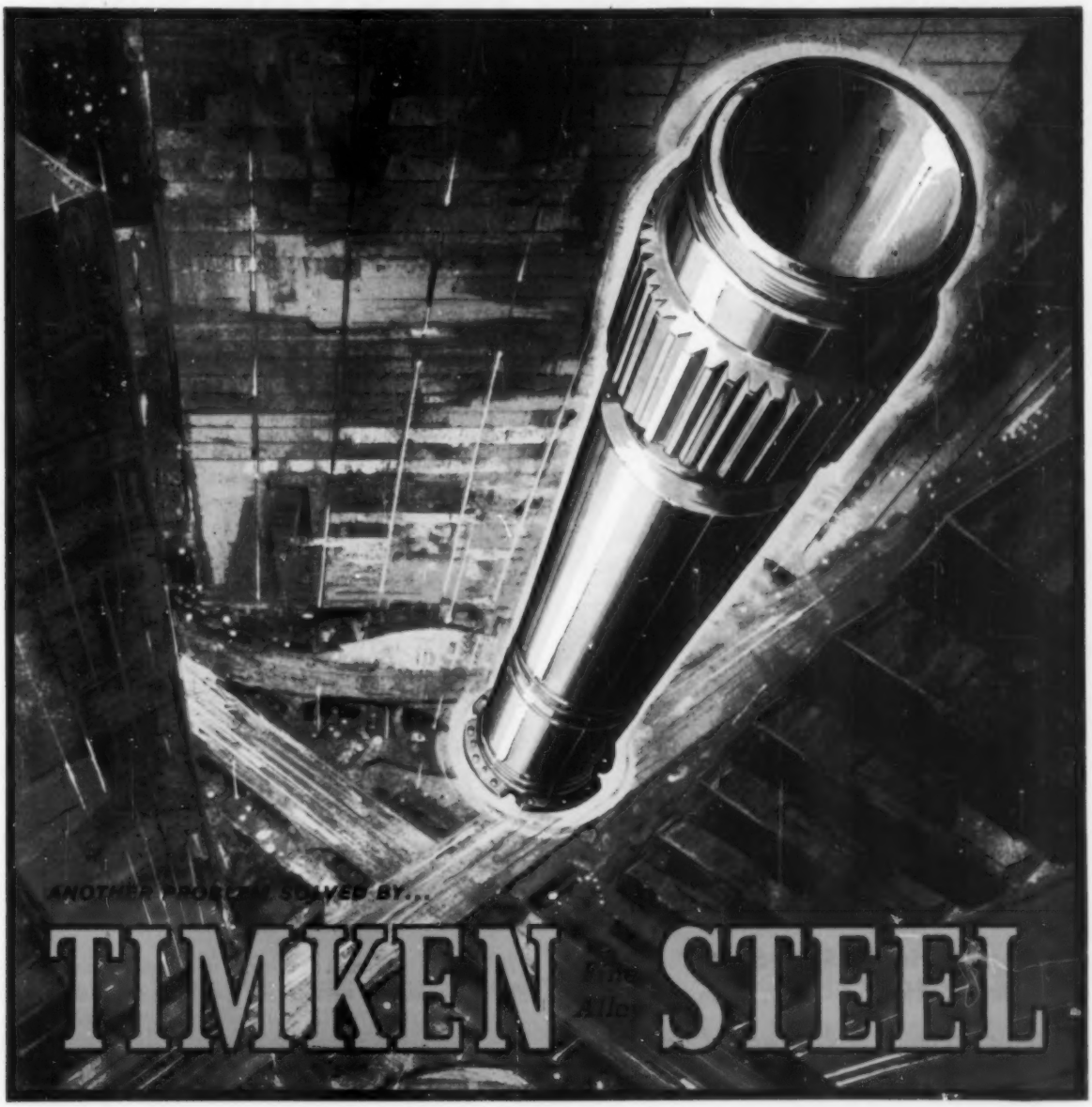
Shown below is the main rotor shaft of a new model helicopter. Because it was hollowed out of solid steel bars to save weight, it was costly to make. After machining to thousandths of an inch accuracy, previously undetected steel flaws showed up. One out of every five parts had to be rejected.

Timken Company Metallurgists were consulted. After careful study, they recommended a special analysis of Timken® seamless steel tubing. Savings began immediately. Because the hole was already there, no drilling was required. Steel was saved. And with the extra advantage of uniform forged quality in Timken seamless tubing, rejects of finished parts were practically nil.

Let us help you cut your costs, get better quality finished products. Our engineers will recommend the most economical tube size for your hollow parts jobs, one guaranteed to clean up to your finish dimensions. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.*

WHEN YOU BUY TIMKEN STEEL YOU GET:

1. Quality that's uniform from heat to heat, bar to bar, order to order
2. Personal attention from the experts in specialty steels
3. Over 40 years experience in solving tough steel problems



TIMKEN ALLOY STEEL AND SEAMLESS STEEL TUBING ARE AVAILABLE FROM WAREHOUSE STOCKS IN 44 CITIES IN THE UNITED STATES

Here's why Dayton Variable Speed Cog-Belts® are being used by more machinery manufacturers

The Dayton Variable Speed Cog-Belt is one of the most successful V-Belt designs resulting from today's demands for higher capacities and greater speed ranges in variable speed drives. You'll find examples everywhere . . .

In the textile industry, where 1% speed variation can mean the difference between profit and loss, hundreds of thousands of spindles are driven by Dayton Variable Speed Cog-Belts.

In the appliance industry . . . automatic washer-dryer combinations powered by Variable Speed Cog-Belts have proved to be a quieter, simpler, cheaper means of shifting from 45 r.p.m., the tumble speed, to 200 r.p.m. during the spin cycle.

In the agricultural industry, where complex machinery requires variations of speed and power, Variable Speed Cog-Belts have long been a standard method of precise adjustment to fit various conditions of load and terrain.

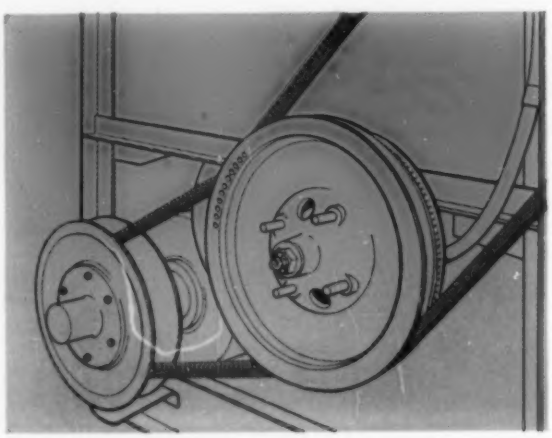
In the metalworking industry, Dayton Variable Speed Cog-Belt Drives are being adapted increasingly.

Why this revolution in speed-change mechanisms? Simply because Dayton Variable Speed Cog-Belts have proved . . . over and over again . . . that they provide a simpler, cheaper, faster way to vary speed and, most important of all, do it with predictable accuracy!

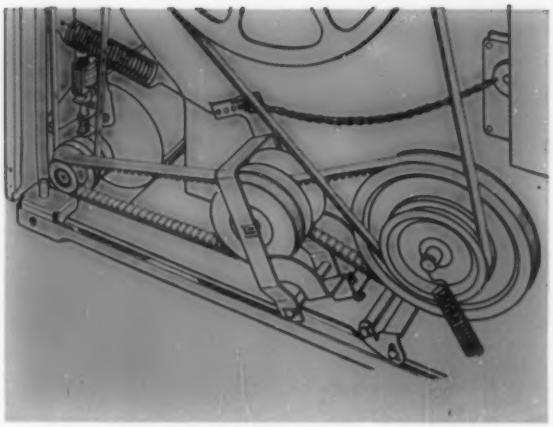
Dayton Variable Speed Cog-Belts offer:

- Extreme longitudinal flexibility needed for easy flexing around the sub-standard diameters often employed in variable flange sheaves.
- Maximum crosswise rigidity to prevent squashing and distortion under high axial pressures.
- The highest pull-out torque of any V-Belt made—due to the surer gripping power of the die-cut raw edges.

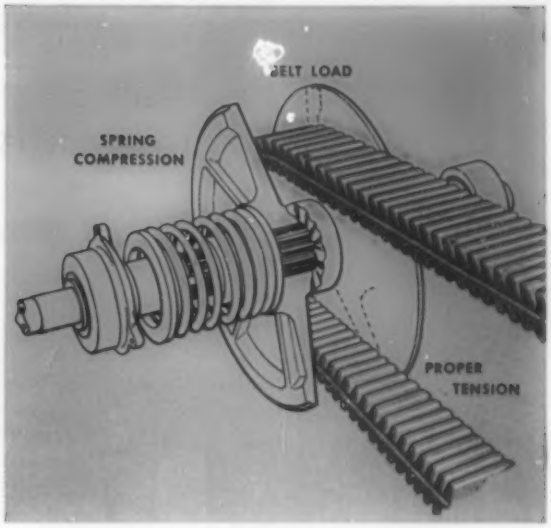
Call the Dayton engineer today and let him show you how you can improve and simplify your design with a Dayton Variable Speed Drive that's accurate at every point in your variable speed range.



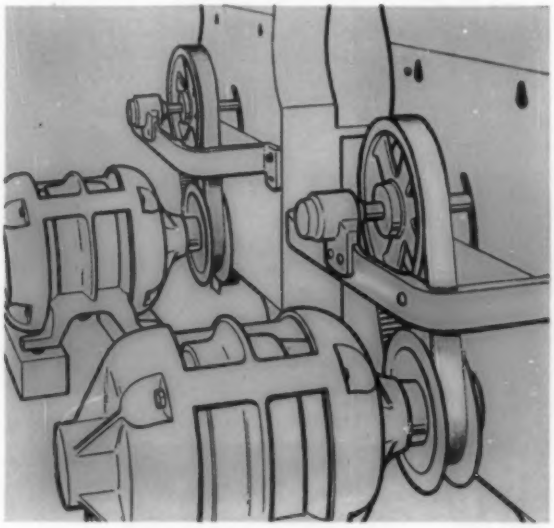
Driven directly from a three-speed transmission, this Dayton equipped variable speed drive transmits inputs of up to 2000 r.p.m. and 70 HP to the traction drive of an agricultural combine. It enables the operator to vary ground speed from 1½ to 14¾ miles per hour depending on the range selected.



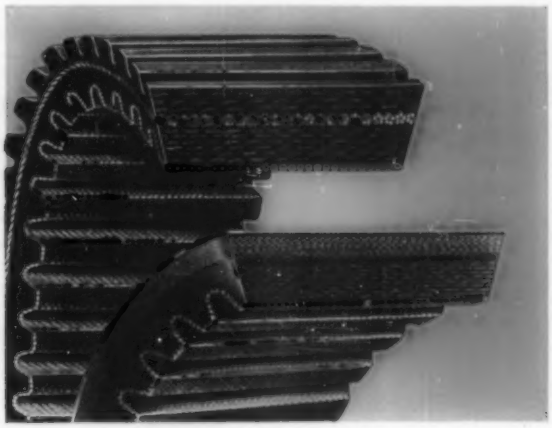
Instead of shifting gears, which have been eliminated in this combination washer-dryer, RCA Whirlpool employed this smooth-performing Dayton equipped variable speed drive to change drum speed from 45 r.p.m. during the tumble cycles to 200 r.p.m. during the spin cycles.



Engineered for maximum crosswise rigidity, Dayton Cog-Belts withstand heavy shock and impulse loads without squashing or deforming. This feature, plus surer gripping molded raw edges, gives double assurance of precise speed control under any operating condition.



For years, textile spinning frames were driven by overhead flat belt drives . . . then interchangeable multiple V-Belt drives. Efficient Dayton Variable Speed Drives, capable of being adjusted within one r.p.m. of optimum speed for unvarying quality and maximum production, now provide the most up-to-date power transmission method.



The exclusive Cog design gives Dayton Variable Speed V-Belts maximum lengthwise flexibility needed for bending around sub-standard diameter sheaves without strain or excessive heat build-up. This stronger, lighter-weight construction operates at speeds up to 2000 r.p.m. with a minimum of centrifugal force or internal stress.

® Registered

Dayton Industrial Products Co.

Melrose Park, Ill. — *A Division of The Dayton Rubber Company*

Industrial Sales Engineers in Atlanta, Chicago, Cleveland, Dallas, Dayton, Minneapolis, Moline, New York, San Francisco and St. Louis

These standard bearings have special qualities

—*does this mean they cost more?*

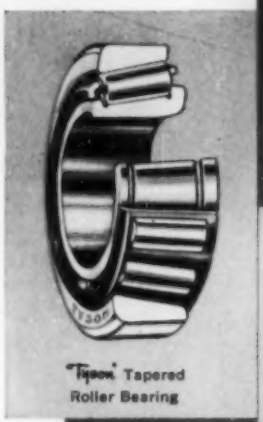
Not necessarily.

*Take the spherical roller thrust bearing, for example. SKF bearings of this type can carry unusually heavy loads: either thrust or combined thrust and radial. Unmatched for single bearing performance when high thrusts must be carried at high speed. And they are completely self aligning. Because of these qualities, engineers choose them for heavy-duty applications over large angular contact ball bearings.

Yet this standard SKF bearing is competitively priced. Furthermore, it is promptly available in 25 sizes ranging from 4.3″ to 14.9″ I.D.

Moderately-priced, high-quality ball and roller bearings are continually rolling off SKF's production lines. So why not get all the facts on those you can use? Just call the nearest of our twenty-five sales offices. 5927

Angular Contact Bearing


"Tyson" Tapered Roller Bearing

Single Row Deep Groove Bearing

Spherical Roller Bearing

Cylindrical Roller Bearing

*Spherical Roller Thrust Bearing

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

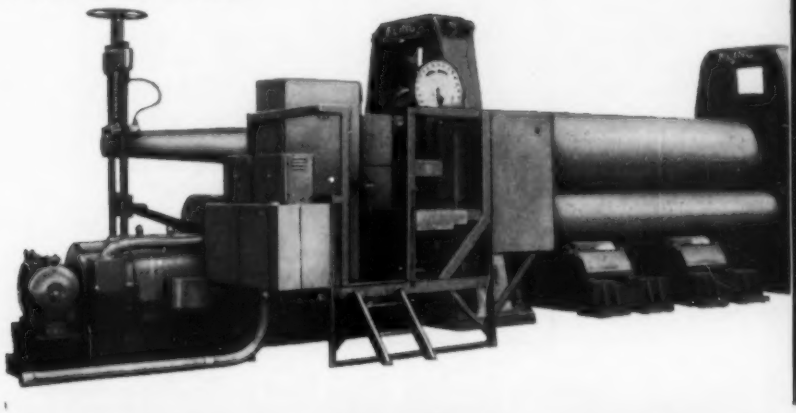
EVERY TYPE—EVERY USE

SKF®

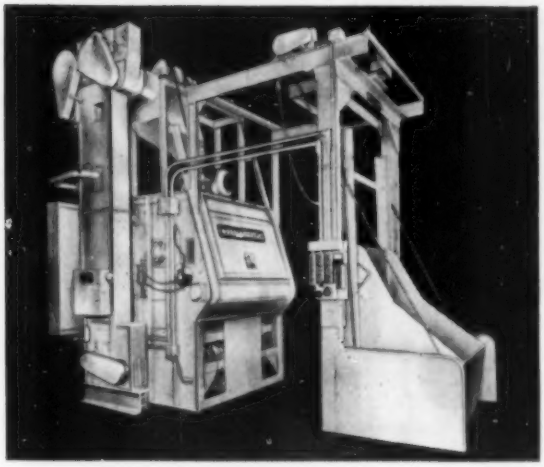
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

®REG. U. S. PAT. OFF.

The Kling Brothers Engineering Works manufactured this steel plate bending roll for one of the leading shipbuilders . . . it's completely equipped with Cutler-Hammer Motor Control and magnetic brakes.



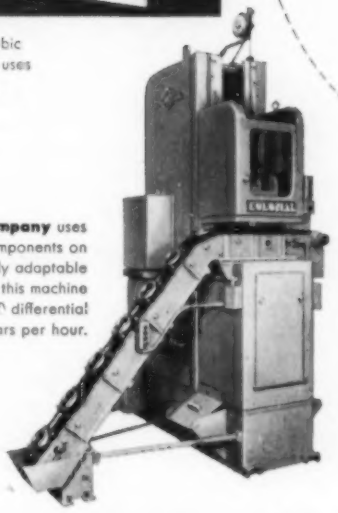
American Machine & Foundry Company's Glen Mixer, used by the baking and pharmaceutical industries for mixing large batches, features Cutler-Hammer Motor Control.



The Wheelabrator Corporation's 14 cubic foot Super Tumblast abrasive blast cleaner uses Cutler-Hammer Motor Control as standard original equipment.

CUTLER-HAMMER CONTROL C-H

Choice of the leaders . . . the mark of better machines



Colonial Broach & Machine Company uses Cutler-Hammer Control Components on their RU 15-48 model. Easily adaptable to fully automatic operation, this machine is capable of broaching 300 differential ring gears per hour.

The proper performance of any machine requires dependable, trouble-free service from the motor control which directs and protects it. This is why leading machinery builders use Cutler-Hammer Control. It installs easier . . . works better . . . and lasts longer. For prompt attention to your control requirements write Dept. N-249, Cutler-Hammer Inc., Milwaukee 1, Wis.

CUTLER-HAMMER

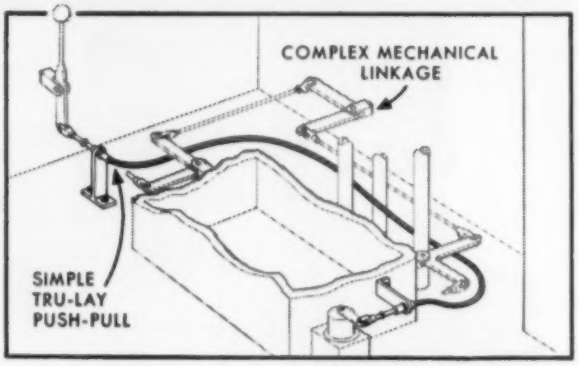
Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* **Airborne Instruments Laboratory.** • *Subsidiary:* **Cutler-Hammer International, C. A.**

Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation

with TRU-LAY PUSH-PULL controls, you can---

MAKE HUNDREDS OF PRODUCTS MORE USEFUL, EASIER TO SELL

Tru-Lay Push-Pull controls provide positive remote action over long or short distances. Because they operate while flexing, they can snake around obstructions. They are ruggedly constructed, easily installed and operated, and are sealed against dirt and moisture. Push-Pulls are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Linkages, on the other hand, are complex. They're made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Here's Why Push-Pull Controls Simplify Design, Give Better Performance

Long Life—We have never heard of a Tru-Lay Push-Pull wearing out in normal service.

Dependable Operation—Top performance under the most adverse conditions...in temperatures ranging from −70°F to the high levels of jet engine operation...in wet locations...in abrasive atmospheres.

Freedom from Trouble—Inner working member is fully protected by tough, flexible conduit...lifetime factory lubrication...sealed against entrance of dirt, moisture, and other foreign matter...cold swaging of all fittings.

Accuracy—Built to the most exact standards of quality and precision. On automobile pushbutton transmissions, for instance, Push-Pull controls provide five positions with a total movement of only .560".

Capacity—Push-Pull controls will handle jobs with as much as 1,000 lbs. input, 150 feet or more from the control point.

Adaptability—Push-Pull controls can be adapted to countless applications. Standard anchorages, fittings, and heads meet almost any requirement, and modifications can be made to fit special situations.

Design Engineers Report on Benefits

Saves Time, Labor, and Material
"We use Push-Pulls to operate clutch controls on the main power unit, feed conveyors, and delivery conveyors...and we save the time, labor, and material required for planning and engineering the old linkages."

Greater Flexibility of Design
"Push-Pulls give us flexibility in locating the hydraulic control valve in relation to the operator's position."

Cost Less to Install
"They are easier and less expensive to install than linkages for remote control of power take-off."

Solution to Tough Problem
"Can be installed where straight rods are impossible."

Eliminates Maintenance
"No maintenance whatsoever; not even lubrication is required."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods, and other lost-motion devices for remote control of hydraulic valves."

Provide Accurate Control
"We get minimum backlash because the cable is designed to close tolerances with minimum drag and lost motion."

Push-Pulls Can Help Solve YOUR Remote Control Problems

Push-Pull controls are solid as a rod and flexible as a wire rope. You can use them in the electrical, hydraulic, and pneumatic systems on construction equipment, on farm implements...almost *anywhere* convenient remote control is desired. For complete details on how you can use them, write for a copy of the Push-Pull Data File. It contains 7 bulletins which describe in detail the operation of Push-Pulls, their applications, features, and advantages. Our engineers will be glad to help you make Tru-Lay Push-Pull controls a part of your product.

Automotive and Aircraft Division
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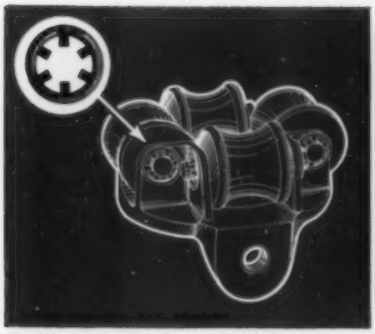
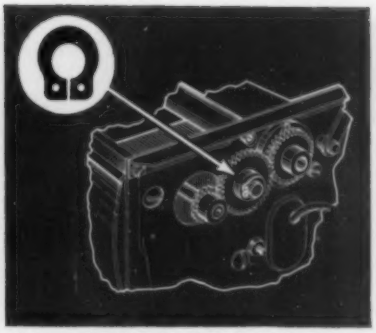
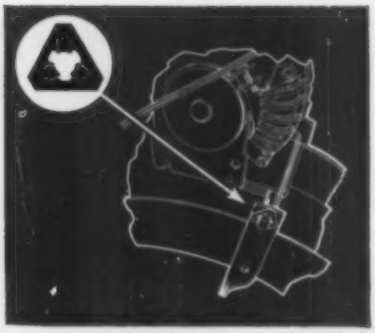


Drilling and flaring eliminated. Easier maintenance, a time saving of 50% and elimination of costly, time consuming drilling and flaring operations result when Truarc Series 5115 self-locking rings are used to retain rollers on pins in this electric cable guide. Extra long prongs enable ring to accommodate wide shaft tolerances.

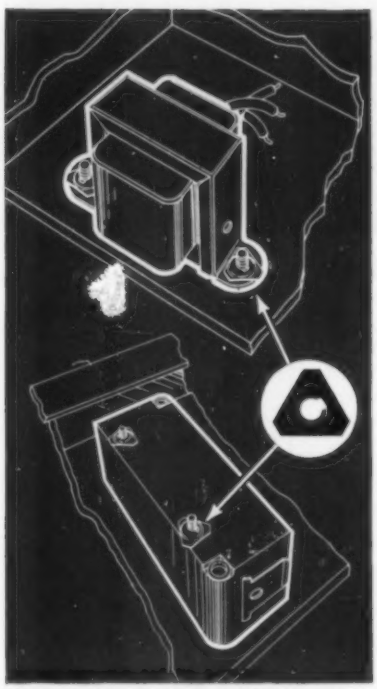


Economical fastening for idler gear. Installing Truarc Series 5555 Grip Ring flush with hub insures precise seating of gear in this portable electrocardiograph assembly. What's more, the ring eliminates a nut and costly stud-threading operation of alternate design. **Typical savings amount to $365 per 1000 units.**



Cross-drilling and cotter pin eliminated. Here a Truarc Series 5305 self-locking triangular retainer replaces a cotter pin used to hold an electric-motor mounting bar. Both the cotter pin and the cross-drilling operation required in the original design are eliminated. **Typical total savings amount to $120 per 1000 units.**

Truarc self-locking retaining rings boost economy in wide variety of designs



Easy way to mount electrical-electronic parts. Truarc Series 5300 triangular nuts replace conventional nuts and lockwashers in mounting electrical parts like transformer (top) or Microswitch (bottom). Dished body of Series 5300 flattens under torque, eliminates need for lockwasher, simplifies handling and assures assembly.

...eliminate parts, machining, speed assembly

Easy application, elimination of more expensive conventional fasteners and reduction or elimination of machining operations are just a few of the savings resulting from the proper use of self-locking retaining rings. Rings replace threaded retainers and nuts, hairpin-type cotter pins, and a variety of cut, lock, and plain washers. They require no groove, or preparatory machining operations. Rings can be installed by unskilled labor, seated at any point on the shaft, automatically taking up any accumulated tolerances.

Four ring types are shown. One has a dished triangular body which locks the fastener on the shaft under spring tension, holds under moderate shaft tolerances and against extremely heavy thrust loads. Another, a re-usable Grip Ring, is ideal for ungrooved shafts, tubes, bosses, and studs. A third type is a triangular free-spinning nut with a dished body that flattens under torque, eliminating need for separate lock washers. The fourth, a push-on type, has an arched rim to provide high strength and extra long locking prongs which accommodate wide shaft tolerances.

These are but four of the 50 functionally different types of Truarc retaining rings. They come in 740 standard sizes, 6 metal specifications, 13 different finishes. The entire Truarc line, including assembly tools, grooving tools, and 80 typical cost-saving applications, is covered in the new catalog RR 10-58. And remember, Waldes engineers are always ready to help you solve your application problems—whether they involve one of the standard Truarc rings or a "special" to fit your particular requirements. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y. 0.15

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TRUARC®
RETAINING RINGS
Waldes Kohinoor, Inc., Long Island City 1, N. Y.

TRUARC RETAINING RINGS . . . THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

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Variety in design and material
Uniformity in quality and performance

In solid bronze, or steel faced with lead or tin-base babbitt, or sintered copper-alloy or bronze on one or both faces. They are cold rolled for heavy-duty operation. Flat, spherical or special shapes, with coined oil grooves, ball indentations on one or both sides, holes, nibs, lugs or scallops. Up to 5″ O.D. Extensive manufacturing facilities. Quality control. Complete engineering service.

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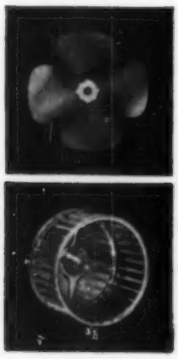
This means complete technical data and the proved-out performance rating on three lines of basic blower unit designs.

In addition to the standard direct drive units and the already famous VariBasic belt driven series, latest and most spectacular addition is the exclusive Radiax unit, combining the optimum performance characteristics of both radial and axial flow techniques.

The result is FULL COVERAGE – the best "problem insurance" you could have.
Talk to Torrington!



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CIRCLE NO. 25 READER SERVICE CARD

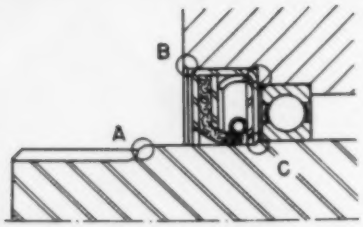
NATIONAL OIL SEAL LOGBOOK

4 common shaft sealing conditions

. . . and engineering tips that can help you "design-in" better oil seal performance

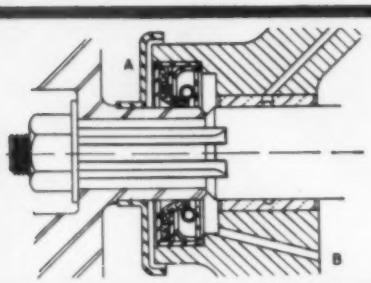
CONVENTIONAL INSTALLATION

Here a standard-design single lip seal retains lubricant and excludes normal dirt, dust and moisture. Sealing lip points in since seal's principal job is retaining oil or grease around bearing. Note that shaft is stepped and chamfered at "A" to prevent damage to sealing lip during installation. At "B", bore is chamfered to facilitate seal entry. At "C", counterboring insures accurate positioning of the seal.



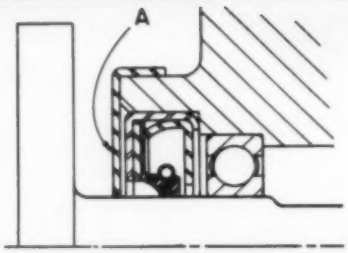
HEAVY DIRT CONDITIONS

Here is a commonly used method of protecting the seal and increasing seal life on applications subjected to extreme dirt conditions. The guard baffle at "A" is welded or swaged to the wheel hub to exclude the major portion of dirt and dust. The drain hole at "B" relieves pressure at the sealing point. In addition to the guard baffle, many manufacturers employ a dual-lip seal to insure bearing protection under extreme dirt conditions.



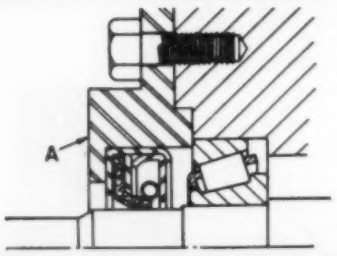
SEALING LONG, HEAVY SHAFT

Many cases of so-called "seal failure" are due solely to poor installation techniques. While today's seals are rugged, they can be rendered non-serviceable if distorted out of round, cocked in the bore, or if the sealing lip is torn. To protect the seal against such physical damage during installation involving a long shaft, a seal protector as shown at "A" may be mounted on the hub O.D.



INSUFFICIENT DEPTH TO MOUNT SEAL

Where the housing does not provide sufficient depth for counterboring, or where seal installation would be difficult or likely to damage the seal, a separate mounting member ("A") can be employed. As before, the shaft should be chamfered to prevent damage to the sealing lip during installation.



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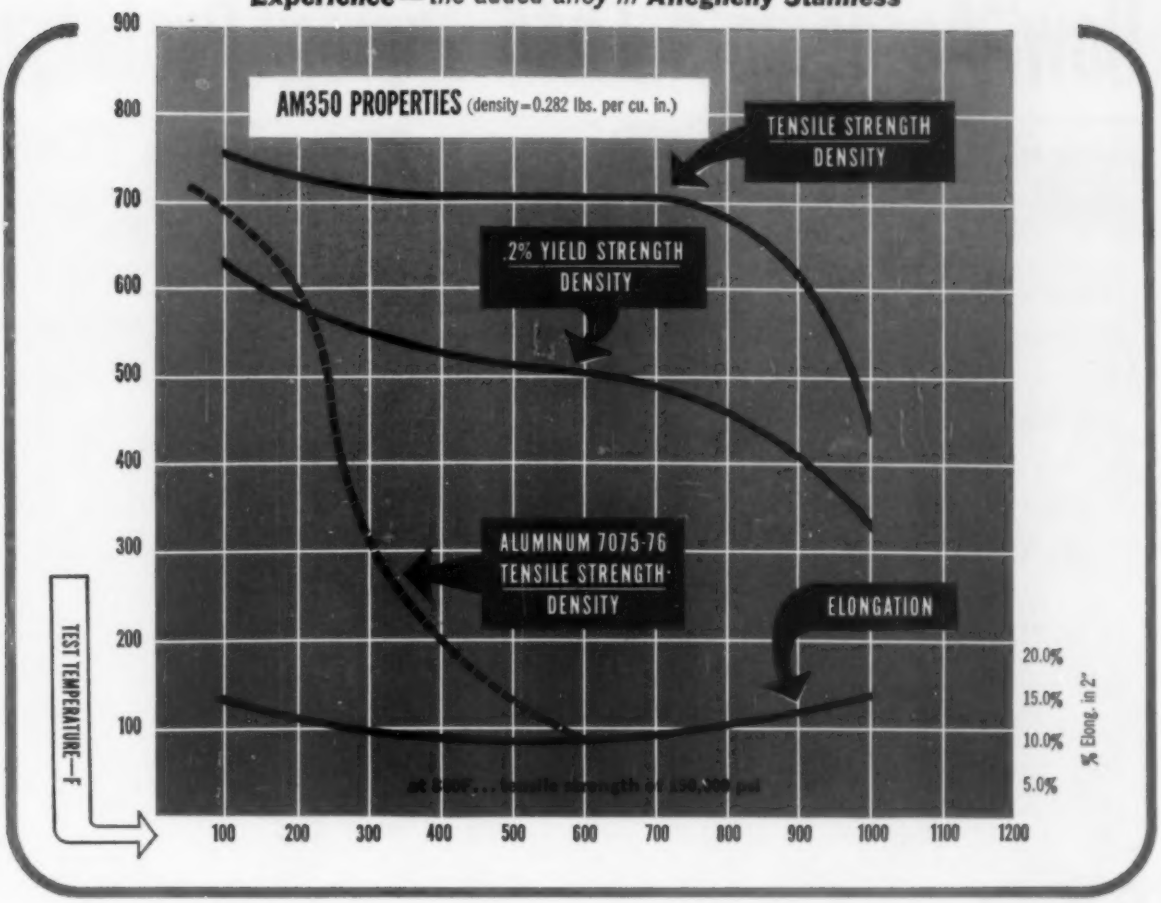

Two for the space age—AL's AM-350 and AM-355 precipitation hardening steels

A unique combination of highly desirable properties describes Allegheny Stainless AM-350 and AM-355 Steels. They combine high strength at both room and elevated temperatures, excellent corrosion resistance, ease of fabrication, low temperature heat treatment, good resistance to stress corrosion.

They are proving the answer to many space age problems. Airframe and other structural parts, pressure tanks, power plant components, high pressure ducting, etc. are all natural missile and supersonic aircraft applications for AM-350 and AM-355.

AVAILABILITY: AM-350, introduced several years ago, is available commercially in sheet, strip, foil, small bars and wire. AM-355, best suited for heavier sections, is available commercially in forgings, forging billets, plates, bars and wire.

CORROSION RESISTANCE: Compared to the more familiar stainless grades, AM-350 and AM-355 resist corrosion and oxidation better than the hardenable grades (chromium martensitic) and only slightly less than the 18 and 8's. They resist stress corrosion at much higher strength levels than do martensitic stainless grades.

SIMPLE HEAT TREATMENT: High strength is developed by two methods. Both minimize oxidation and distortion problems. The usual is the Allegheny Ludlum-developed sub-zero cooling and tempering (SCT): minus 100F for 3 hrs plus 3 hrs at 850F. Alternate method is Double Aged (DA): 2 hrs at 1375F plus 2 hrs at 850F.

EASY FABRICATION: AM-350 and AM-355 can be spun, drawn, formed, machined and welded using normal stainless procedures. In the hardened conditions, some forming may be done . . . 180 degree bend over a 3T radius pin. Also AM-350 can be dimpled in the SCT condition to insure accurate fit-up.

For further information, see your A-L sales engineer or write for the booklet "Engineering Properties, AM-350 and AM-355." ***Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pa. Address Dept.*** *PE-19*

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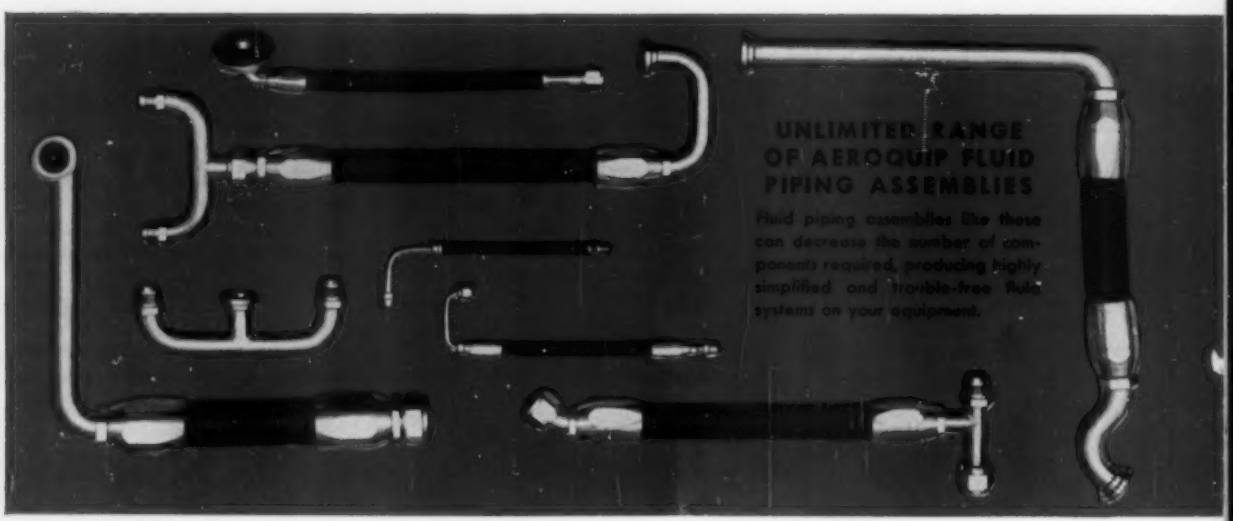
Aeroquip field engineers work right with your engineers in building prototypes, assisting in testing and modification of fluid systems to get good performance and long service in the field.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Fluid piping assemblies like these can decrease the number of components required, producing highly simplified and trouble-free fluid systems on your equipment.

Service Assists Manufacturing Firms

AEROQUIP'S EXPERIENCE SIMPLIFIES FLUID PIPING ENGINEERING AT THE PROTOTYPE STAGE, ELIMINATES POSSIBLE FUTURE PROBLEMS FOR MANUFACTURERS OF MAJOR EQUIPMENT

Checking fluid piping performance on equipment prototypes is an important part of the complete fluid piping service provided by Aeroquip's skilled engineering team.

This is the right point in equipment development for experienced Aeroquip specialists to check routing, sizes, support clamping, lengths, fittings and adapters on fluid piping for equipment and make recommendations for maximum performance and long life. Many problems that might arise on the production line can also be avoided at this stage.

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With Aeroquip's prototype installation report as a guide when making production drawings, hours of drafting time are saved.

Properly engineered fluid piping on your equipment assures increased user satisfaction and fewer field service complaints. Aeroquip Flexible Hose and Reusable Fittings greatly reduce downtime and replacement costs.

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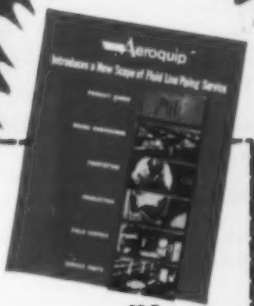

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Aeroquip Corporation, Jackson, Michigan

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☐ Please have an Aeroquip Sales Engineer call on me to discuss this service.

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NEW Solenoid Valve V-4019

for water and other light fluids

small in size, high in capacity

APPROXIMATE CAPACITY, GALLONS PER MINUTE, WATER SERVICE

Differential Pressure (psi)	1.25	3	5	10	30	40	50	100
½" Valve	5.6	8.7	11.3	15.6	27.3	31.6	35.2	50
¾" Valve	7.8	12.1	15.6	21.9	38.2	44.2	49	70

Pressure Ratings: Operating pressure—100 psi max.; 1¼ psi min. for full flow. Body rating: 150 psi, nominal body rating

Fluid Temperature Ratings: 125 F max. at 125 F ambient
175 F max. at 77 F ambient

Capacity Index (C_v): ½" size—5, ¾" size—7

Electrical Rating: 120, 208, 240 volt, 50 and 60 cycle ac

Use this pilot-operated, soft-seated solenoid valve for reliable on-off control of water or other light, non-viscous non-corrosive fluids. It's of floating-piston design for quiet operation. The power head can be rotated 360° for ease of wiring. Body material is brass. Can be used for normal and chilled water applications . . . operates from any standard SPST controller or on-off switch.

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Tiny Living Heat Exchangers. Some species of deep sea fish have countercurrent bundles of blood vessels (rete mirabile, shown twice actual size) so efficient that if boiling water and ice water were counterflowing in them, heat transfer would be complete to 1/10,000 of a degree!

Miniature Pressure Transducer for airborne instrumentation, 1″ long, 1″ O.D., withstands accelerations in 3 planes up to 40g with error less than 1%. Utilizing low-torque characteristics, 2 MPB bearings provide capacity, life and maintain exacting precision of a sensitive linkage.

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Man is making fabulous progress in his ceaseless fight against friction and inertia. Today's machines operate at fantastic speeds and accelerations . . . on earth . . . in the sky . . . and beyond. But space for components daily becomes more precious and while bearings used in these machines must have tremendous stamina, many of them must be almost unbelievably compact. MPB makes over 500 types and sizes of such bearings ranging down to 1/10″ O.D. Send for illustrated catalog describing them. Special bearings supplied when necessary. Design assistance at your request. Write **Miniature Precision Bearings, Inc.,** 208 Precision Park, Keene, N. H.

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That burly dozer. It's precision built! It's strong! Its massive blade can tear the side out of a hill. Yet, it's nimble, too. In spite of a crab-like figure, it can stop with a jolt, back off, spin, dig in and charge with the force of a galloping rhinoceros.

Power is jammed into these machines. That's why they're built with the toughest, most durable materials in the world. For years, leading manufacturers have chosen USS Shelby Seamless Mechanical Steel Tubing for hydraulic cylinders, tractor pins, bushings and more than 100 other vital parts in earthmoving, rockmoving, grading and all types of heavy mobile equipment. *Why?* Because Shelby Seamless Tubing is ideal for the fabrication of machine parts subject to bruising performance and long wear.

USS Shelby Seamless Mechanical Steel Tubing is another product from the world's largest manufacturer of tubular materials. For more than 80 years, National Tube has been foremost in building and industrial pipe applications. For more information, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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DEVELOPMENTS TO WATCH...

Coils wound with aluminum strip are near commercial production . . .

. . . says Robert R. Cope, Alcoa's Strip Conductor Program chief. Several manufacturers are working on them, and the first are expected to be on the market "within a year." Some of the companies planning to produce them will market the coils themselves; others will make their own for use in such devices as transformers and solenoids.

Biggest advantage of the aluminum strip is expected to be economy; but, says Alcoa, performance will at least equal that of standard copper wire coils.

Alcoa is now gathering performance data from the companies to which it has supplied test coils, expects to release a complete performance report this coming fall.

New line of thermistors . . .

. . . being introduced by Plessey Co Ltd, Wood Burcote Way, Towchester, Northants, England, offers a wide selection of shapes, sizes, and resistances for applications ranging from temperature measurement and control to relay timing, voltage regulation, and measurement of fluid flow.

Four different materials (metal oxide mixtures) are used in the line, formed into disks, bars, rods, washers, and beads (all metallized except the beads). Glass-enclosed units have a maximum operating temperature close to 500 F; the others, 300 to 400 F.

Thermistor-users on this side of the Atlantic, incidentally, should welcome a slide calculator now obtainable from Fenwal Electronics. It includes dimensions, dissipation and time constants, and maximum temperature limits for "several hundred" possible combinations, has a five-scale slide that makes it possible to "read resistance directly opposite all temperature points on the curve of the appropriate thermistor." The "Thermistor Data & Curve Computer" is 5 by 8 in.; priced at $1; from Fenwall, Framingham, Mass.

More data on damping capacity of metals and alloys . . .

. . . will soon be coming from the Bureau of Mines. Just published is a memorandum outlining test methods and terminology, designed to serve as background for reports on specific findings being readied for early release.

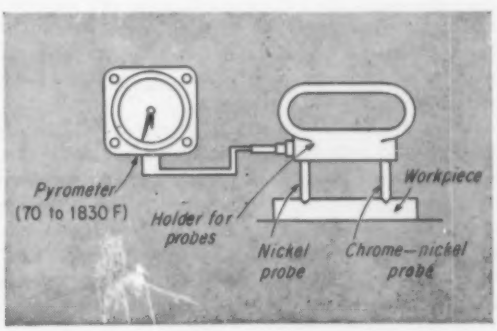
Although alloys that have high damping capacity may be deficient in some other respects (ductility and yield strength, for instance), Bureau of Mines researchers believe the property itself is so valuable that compromise is often well worthwhile, and more attention is likely to be paid to damping capacity in the future rather than less. That has already been the case for marine applications, as witness the fact that the Bureau of Ships has supported research on high-damping manganese-copper alloys for a number of years.

Among the most promising new alloys, the Bureau of Mines says, are a group of magnesium alloys which offer excellent ductility and high damping capacity, though their yield strength still leaves something to be desired. The Bureau is now working on these alloys; has a long-term research program scheduled to extend through 1960.

Copies of the background report, RI 5441, are free from Publications Distribution Section, Bureau of Mines, 4800 Forbes St, Pittsburgh 13.

High-speed temperature gage . . .

. . . for hot metal (sheet materials heated for stamping, for instance) is designed to replace systems that use two soldered points for control. The gage, designed in Czechoslovakia, consists simply of a frame or holder from which two probes (one nickel and one a chrome-nickel alloy) extend downward so their sharp tips can be pressed into the work, "piercing the oxide layer and permitting an almost instantaneous temperature reading" on the gage.



Czech temperature-sensor is pressed into workpiece to give faster reading on pyrometer. Handle, through which pressure is exerted, is made of heat-resistant material.

DEVELOPMENTS TO WATCH...

Fractional-horsepower motors that conform to American . . .

. . . as well as British standards have been designed by Crompton Parkinson Ltd, Aldwych, London, WC 2.

Featuring a center height of only 3 in., they are believed to be the first UK fhp motors to conform to the NEMA 48 standard.

Provision is made for several types of mounting, including solid-foot, resilient, end-face, oil-burner flange. Other improvements: smaller winding slots, made possible by improved wire and insulating materials; improved processing for magnetic materials that "eliminates low density areas and enables core sizes to be reduced"; polyvinyl acetal resin insulation that improves mechanical as well as electrical strength of stator windings.

Ratings range from 1/20 hp at 960 rpm to ½ hp at 1425 rpm (three-phase); and from 1/40 hp at 960 rpm to ½ hp at 1425 rpm (single phase).

Data on electrical insulating liquids . . .

. . . presented by L. Chiabotto of Esso Standard Italiana to the World Petroleum Congress, indicate the importance of testing—and specifying—properties other than dielectric strength.

He points out that, in capacitors, lower power factor, cooling ability, and non-gassing qualities are at least as important as dielectric strength. In power cables, low power factor and low dielectric constant are key qualities. Even in transformers, where dielectric strength does rate top consideration, electrical oxidation stability and cooling ability must also be considered.

Further, he notes, standard tests for dielectric strength are far from reliable. He considers power factor the most useful single test to assess the quality of insulating liquids, because as differentiated from the resistivity test, it takes into consideration both polar and conductivity effects.

Concerning specific types of oil, he says: "For a conventional transformer oil, whose peculiar characteristic is to insulate, the increase of power factor with temperature is very great. White oil presents the best electrical properties but has the deficiency of developing gas under electrical stress. When comparing paraffinic and napthenic oils from the point of view of the variation of power factor it has been found that the temperature influence on power factor is lower for paraffinic oils. For cable and capacitor oil, the necessity of special types with very low power factor and little sensitivity to temperature variation, must be emphasized.

"The best behavior of the light white oil USP was found to be the power factor. Notwithstanding, this oil cannot be prescribed for use in oil-filled cables, owing to its gassing tendency. Also, for this same reason, it is not satisfactory for general use in capacitors."

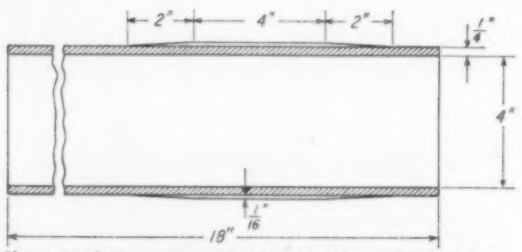
Research, at Trieste, Italy, is continuing.

High-speed shuttering device . . .

. . . that takes advantage of sheet explosives (*PE*—Apr 13, p 62) has been developed at Stanford Research Institute. Its primary aim: to protect instrumentation and other equipment from high-velocity fragments during hydrodynamic studies. But SRI researchers believe it may have much broader application.

Construction of the device is extremely simple. It's just a steel tube (see diagram) through which the instrumentation views the test event. This is wrapped at its center with a tapered sheet of explosive, and surrounded by water.

With a tube of the size diagrammed, SRI says, total closing time is about 112 millisec, and tube size can be scaled up or down considerably without affecting performance. In the smaller sizes, though, sheet thickness becomes critical. An alternate method for small tubes, which dispenses with the water barrier, involves flattening the tube slightly prior to use and wrapping it with strands of explosive instead of sheet material. A ⅜-in.-ID aluminum tube with a wall thickness of 1/16 in. can be collapsed in 30 millisec this way.



Sheet explosive wrapped around tube collapses it on signal to protect instrumentation during high-explosive tests.

When explosive sheet is used, minimum charge length is about two pipe dia; and, at its center, the sheet should be about ¼ as thick as the pipe wall.

—ARG

Plastics in Foreign Cars on the Up-swing

How and why foreign cars are ahead of Detroit in plastics application. A McGraw-Hill World News study of 7 key countries.

DETROIT—Do foreign car-designers like plastics as engineering materials? Answer seems to be an emphatic "yes," according to DuPont's Dr Robert E. Burk, who presented his survey of leading foreign car manufacturers to a special, one-day SPE meeting in Detroit. Reports Burk: "Engineers both here and abroad are specifying more plastics each year, but the pace of this acceleration in Europe is quicker than it is here."

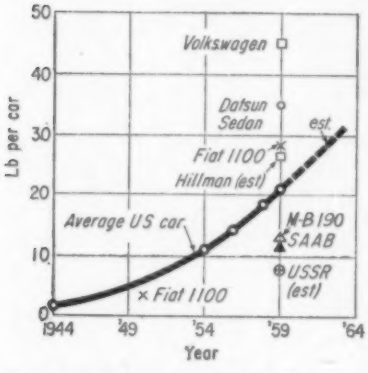
Reasons for this rapid, almost explosive acceleration (see chart) go beyond the usual European imperatives of economy and light weight. Dr Burk cites three, all of them international in origin:

(1) Manufacturing side of the plastics industry has grown up—resulting in materials to close specifications, and new processes to form them.

(2) Design in plastics has become a science. Organized engineering data are more widely available—making for reliability and confidence.

(3) Growing number of tough, rigid thermoplastics like new nylons, polyolefins, acetals, ABS-blends presents broader property choice in competition with metals.

Despite the stronger interest in plastics shown by Dr Burk's survey of European automakers, designer acceptance of these materials is no more uniform outside the US than it is in Detroit (*PE*—Mar 24 '58, p 27). Attitudes vary from country to country—reflecting economic conditions, consumer tastes, status of plastics industry, and even national temperament. To probe some of these variations, PRODUCT ENGINEERING's overseas editors asked some sharp questions of automakers in their respective countries. The responses, country-by-country, cover not only basic attitudes but unusual uses of specific plastics, and technical developments.



Foreign designers outstrip U S . . . in pounds of plastic per car. Not only is the total higher, but the foreign rate of usage is higher too. Figures here have been corrected for weight disparity, using a 4-door Chevrolet at 3750 lb as a base. Thus 43.5 lb listed here for a Volkswagen represents 20 lb of actual weight.

GREAT BRITAIN

LONDON—British automakers are well behind those of the Continent in specifying plastics in mass-produced cars, principally because of consumer distrust. Nonetheless, there's a strong streak of innovation here based on reinforced plastics R & D coupled with British excellence in aircraft design. Reinforced-plastic bodies are on an increasing number of sports cars. Latest of these is Peerless GT, a 4-passenger family sports coupe with a chassis-hung body of 57 separate plastic moldings. This car sports fiber-reinforced polyester bumpers, impregnated to look like anodized aluminum.

Aircraft monoque design is creeping in, with the new Lotus Elite sports coupe featuring a frameless integral body-chassis. This epoxy-glass structure has three built-up subassemblies—front, top and rear, and floor. Four types of stiffening help carry local loads: glass honeycomb sandwich for the roof, rigid foamed plastic sheet for doors, perforated sheet steel inserts at suspension reaction points, and a steel roll-over tube over the windshield.

Other novel developments include:

- Infiltration of reinforced-plastic parts on metal bodies is expected, by 1965, to include: gearbox casings, hood, trunk lid, driveshaft tunnel, fenders and seat frames.

- Automated "dough molding" techniques are under development by four concerns, including English Electric Co and Bristol Aircraft Co. Main feature of the Bristol process, originally devised for missile nosecones, is close viscosity control so that metered amounts of resin, accelerator, and catalyst can be injected into the mold containing the glass laminate or mat. Properties and finish of the parts are reportedly consistent at high production rates and quantity manufacture. Pilot car bodies by this technique are expected within 5 years.

- Urethane foams are gaining on foam rubber for seat cushioning. Austin Motor Co says it's working on a one-piece molded seat in which a high-density polyethylene shell is filled with foam-in-place polyester urethane.

- Newer, rigid, higher-melting thermoplastics (*PE*—Sep 29'58, p 36) are beginning to get preference over traditional phenolics, following continental Europe's lead, for many structural applications. Principal reasons: they mold faster and color easier, which offsets higher cost/lb.

Despite innovations like these, there exists a basic clash of attitudes on plastics R & D between the auto and plastics industries that is a deterrent to expanded plastics usage. Auto people say they would use more plastics if better ones were researched, pointing out that car usage by 1970 could equal total British plastics production (0.7 billion lb in 1956). Plastics industry, reluctant to commit itself to one market, retorts that auto designers aren't using suitable plastics already developed—citing European designers as being more alert. —John Tunstall

FRANCE

PARIS—Certainly the most interesting use of plastics in any mass-produced French car are found in Citroen's DS-19, which sports a great deal of nylon under its fiber-reinforced plastic roof. Most of it is in complex dashboard

moldings of nylon-11 (Rilsan), a French-developed polyamide based on castor oil (*PE*—Dec '57, p 76), and having lower moisture absorption than nylon-66. The DS-19 features about 50 yd of nylon tubing in its hydraulic suspension system and its fuel lines, as well as a nylon 8-bladed radiator fan. Acrylo-nitrile-butadiene blends are second on the list, used in under-dash panels and heater ducts.

Although designers of a luxury car like the DS-19 (US price: approx. $3245) could afford to use plenty of nylon, designers of the Simca Aronde Deluxe (approx. $1700 here, despite the name) had to stick to lower-cost materials. PVC is the dominant material—used in fuel line, headlight and grille gaskets, windshield washer tank, and all interior covering except flooring. ABS-blends are used in quantity for interior trim parts like molding strips and compartment doors. Nylon turns up only in speedometer gearing.

Renault, largest French auto producer, has upped its percentage of plastics 42% from 1957 to 1959, and uses nylon freely even though its cars are classed "low price." Nylon gets the nod in door handles, heater shutter, air filter, oil filter, ball-bearing holders and accelerator linkage parts.

Despite this progressive attitude toward plastics, French auto engineers are reluctant to predict future usage, expect that it will surely increase. They are, perhaps, keeping a weather eye on the changing moods of the French consumer. —Arthur Erikson

GERMANY

BONN—With an economy geared to high volume and low profit per item, West Germany has a consumer attitude much like America's; product quality and diversity are in demand.

Plastics play a large part in this thinking. Current emphasis is on safety—a consequence of higher auto speeds and more crowded expressways. Thus, foam plastic padding has been added to sharp corners on sun visors, dashboards, instrument clusters and the like. Though US cars use PVC heavily in these areas, German cars carry much more vinyl plastic when all applications are totaled. Reasons for this: heavy German commitment to PVC during the war as a metal substitute, and its ease of fabrication by seam welding. Interest in phenolics continues high too—since there is less emphasis on color styling here. Thus the M-B 190 uses phenolic window trim moldings, dash parts, and electrical system components—for a ratio of 4:1 over US cars.

Echoing Detroit, engineers at Daimler-Benz and Volkswagen agree that the ideal automotive plastics should process like thermoplastics, but wear like thermosets. Specifically, German designers want new, low-cost plastics that have

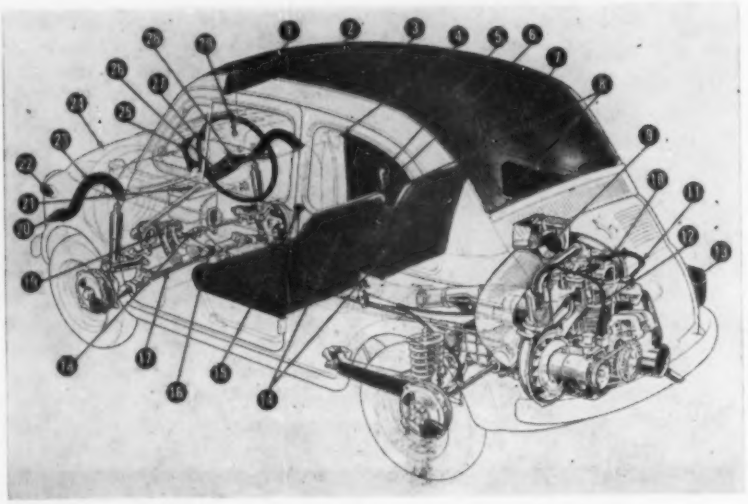
- Higher resistance to elevated temperatures.
- Increased mechanical strength from −40 F to 160 F.
- Thermal expansion coefficients more in line with metals.
- Less plasticizer diffusion to eliminate discoloration of paint work.
- Better resistance to automotive fuels and lubricants.
- Lower moisture absorption and better tolerance retention.
- Better resistance to wear.
- Improved resistance to cold flow.
- Lower corrosivity (tendency to form electrolytes in moist conditions) to reduce plastic-metal bond corrosion.

A probable doubling of plastics in German autos in 1965 depends, according to Daimler-Benz engineers, on whether plastics suppliers can solve these problems. Lack of standardized grades of plastics (instead of tradenames) and uniform testing methods are additional barriers.—Jim Morrison and Silke Brueckler.

ITALY

MILAN—Family car design in sunny Italy means FIAT—where, at Torino, they employ 22,000 autoworkers. FIAT's use of plastics is increasing (see chart) but not fast enough, according to the company's plastics experts. Excessive R & D costs seem to be the reason. Even though FIAT has extensive materials labs and full-scale production facilities (injection molding, extrusion, calendering, compression molding and vacuum forming), high cost of experimental dies discourages wide field trials.

On the other hand, manufacturers and suppliers of plastics, like Montecatini, are reluctant to risk R & D costs themselves or even share them with Italian automakers. Despite this basic disagreement, a common one on this side of the Atlantic, plastics are widely accepted on their own merits. Many cars here use more different types of plastics than US autos. The



Plastics in FIAT 500

PVC: (3) roof lining, (8) inside-panels, (10 and 11) cable covering, (12) fuel line, (23) vent-tube lining, (14) seat covering. POLYSTYRENE: (2) mirror frame, (5) crank escutcheon, (21) battery caps, (20) intake sleeve. POLYURETHANE: (9) air-shutter gasket (foam), (18) steering-linkage bearing. POLYETHYLENE: (17) spring liners. POLYPROPYLENE: (1) sun visor. POLYAmide: (16) accelerator-pedal bushing, (19) brake-pedal bushing. ACRYLIC: (13) stoplight lens, (29) blinker lens, (24) medallion, (22) parking lens. ACETYL-BUTYRATE: (28) horn button, (27) steering wheel, (15) shift handle. ABS-blend: (26) light-switching unit, (25) instrument bezel. CELLULOSE ACETATE: (6) crank knob. PHENOLIC: (4) lock knob. CLEAR VINYL: (7) rear window.

FIAT 500, for example (see sketch) uses 10 basic types, including polypropylene and cast urethane rubber parts. This last material, developed in Germany and widely used there in heavy duty vehicles (*PE*—Sep 16 '57, *p* 68), is more widely used in Italian passenger cars than any others. Much experimental work is going on with polypropylene — including molded carburetors, distributor caps, radiator fans and shock absorbers.

Italian car designers want new plastics capable of resisting weather and sunlight, and with good structural properties to 180 F at least—two factors that seem to give them the most trouble. They follow US plastics developments closely and do not hesistate to import materials when competitive indigenous plastics are unavailable. —Gene DiRaimondo

SWEDEN

STOCKHOLM—The nation you connect in your mind with quality steel has been slow to switch to plastics in its auto designs. But with plastics production here roughly tripling since 1950, more use of these materials in Swedish cars is predicted.

Two main obstacles remain, however: the very cold winters, and Sweden's limited economic base for experimentation and model change. The first limits the choice of suitable plastics; the second forces innovation to move slowly. Thus the SAAB motor car, Sweden's latest export to America, uses only 5.5 lb of plastics compared to 20 lb for Volkswagen—a comparative car.

Both SAAB and Volvo (a heavier family sedan) use well-established plastics–vinyls, phenolics, cellulosic, styrene blends, etc. Of the newer plastics, polyethylene (*PE*—Mar 16 '59, *p* 55) is the only one being tried as yet, though Volvo may try silicones and epoxies in specialized applications.

Swedish auto designers want plastics with better strength over a wider temperature range, with less odor and less tendency to discolor. —Curt Agren

JAPAN

TOKYO—Japanese design has broken away from dependency on Western product engineering, and is developing a point of view firmly rooted in ancient tradition of designing for use and function (*PE*—Jan 12 '59, *p* 38). Japan's auto industry has responded to this trend by coming up with a line of vehicles (53,000 units last year) definitely Japanese in character. Included are the Datsun sedan (now for sale in US) and the Sabura, which is designed for substandard roads and may become Asia's Volkswagen. Coming to the US this fall will be Japan's first plastic-body car, the 4-passenger Datsun S-211 sports coupe.

Automobile designers in Japan took a while to break away from thought patterns imposed by long experience with steel, and are still bothered by the fact that plastic properties are often not as uniform as for steel. PVC is the most widely used material, except where bodies are made from reinforced polyesters, with polyethylene creeping in on brake fluid cylinders and battery trays. Fiber-reinforced parts like seat frames, roof liners and doors are being added to standard metal body designs.

Chief problems for automakers here have been brittleness at low temperature, dimensional instability over wide changes in temperature and humidity, and color durability. Despite these drawbacks, experts predict more plastics in Japanese cars—particularly for interior trim. But with the new emphasis on Japan's capacity to produce quality goods, steel should remain dominant for many years in areas where plastics are moving ahead in European cars. —Toshiko Matsumura

SOVIET UNION

Moscow—Plastics are in for a much bigger role in Soviet car industry, with present average of 5.5 lb per car due to increase 8-fold by 1965. Soviet plastics industry is growing rapidly, particularly in its R & D activities (*PE*—Feb 9, '59, *p* 23), and experts here predict the auto industry alone will take 100,000 tons of plastics over the next seven years.

Present uses in Soviet cars do not represent any advances over Western practice, although auto designers reportedly have nylon ballbearings under development and are contemplating wider use of polyethylene tubing in new designs. A new 4-wheel-drive station wagon called "Ogonyok" (Flame), to be shown in New York this summer, has a glass-reinforced plastic body, and will be used for ambulance and postal service. Reports are that this car will be exported to America. —Robert Gibson

Smog-fighters Battle to Clear the Air

LOS ANGELES—There's a considerable difference of opinion as to how best to reduce smog-producing unburned hydrocarbons and carbon monoxide from auto exhaust.

One faction, like the Los Angeles County Air Pollution Control District holds that by limiting the olefin content of gasoline, the amount of hydrocarbons in exhaust is reduced. They feel so strongly, in fact, that legislation to limit olefin content in gasoline sold in the Los Angeles Basin area is being enforced. Naturally, the major oil refineries here have bitterly contested adoption of the local legislation. They argue that specially reformed gasoline completely free of olefins, when burned in an internal combustion engine, produces appreciable quantities of highly reactive, unsaturated hydrocarbons in the exhaust.

But Paul Grimes of the Los Angeles APCD states that olefins are fast smog-formers because of their high reactivity. He believes that anti-olefin legislation will cut eye irritation and damage to vegetation, and also improve visibility by cutting aerosol formation.

THE MECHANICAL APPROACH

Another approach to the problem of smog reduction, a purely mechanical approach is being attempted by the car industry and suppliers.

Thompson Ramo Wooldridge, Inc, and Chrysler Corp are joining design forces to produce automotive exhaust afterburner devices intended to reduce unburned hydrocarbons and carbon monoxide in exhaust (PE–Jan 12, p 25). Objectives of the research, development and testing program are to reduce the cost, size and complexity of afterburners, and perfect them so they will perform reliably for the life of the vehicle–with minimum need for service or parts replacement. "All findings and all design details will be made available to the entire automotive industry," TRW and Chrysler officials promise.

The current prototype version of the Ramo-Wooldridge afterburner was tested by the Los Angeles Air Pollution Control District earlier this year, and is capable of removing approxi-

mately 90% of the unburned hydrocarbons from automobile exhaust. The device also made a similar reduction in the amount of carbon monoxide discharged, according to Mr. Colwell. However, even when mass produced, its cost would run nearly $400 per installation. Also, operation of the afterburner can cause uncomfortable heating in the rear passenger seat.

The afterburner is one of three possible exhaust control devices now being considered for installation on cars and trucks. It operates by adding air to the exhaust by means of an auxiliary pump and heating the mixture in a heat exchanger to a temperature at which rapid and complete combustion will occur. The clean and cooled exhaust is then discharged in the normal manner.

The afterburner also acts as an efficient silencer, and therefore replaces the conventional muffler. It is designed to operate automatically over a wide range of rapidly changing driving conditions, and begins functioning as soon as the engine is started.

Ford Motor Company seems furthest ahead with its vanadium pentoxide chemical conversion of exhaust gases. Mufflers of this design are now being proving ground tested for durability by each of the big three automakers. Even with this, no one hopes for cost less than $50 per unit installed and a lifetime of approximately 25,000 miles. ■

Educators Grope for Curricula to Keep Student Flexible

PITTSBURGH, PENNA—The difficult problem of educating engineers so they will know how to keep abreast of rapid developments in science and technology came under scrutiny here at the meeting of the American Society for Engineering Education.

Discussing the magnitude of this problem, Dr. Harold L. Hazen, dean of the Graduate School of Massachusetts Institute of Technology told the ASEE that "extremely rapid—indeed, revolutionary—change is occurring in the field of engineering" and students today will "have to learn at least one and probably several new fields during their professional lives." These fields are presently non-existent or in embryonic state. Such rapid changes mean that henceforth emphasis must be toward helping students learn how to learn. Mastery of fundamental science and its applications must be presented to the engineering student as a "trial run, an exercise in the learning process which must become an integral part of his active professional life in the future."

Mervin J. Kelly, a research management consultant, said that four years of study are inadequate for the depth of coverage required for today's engineers. Undergraduate work should provide for an "orderly extension of training." Once in industry, a three-year educational program in physics, math and advanced technology during working hours is insurance against danger of an engineer becoming obsolete.

Turning to college training, J. W. Cohen of the Univ of Colorado and director of the Inter-university Committee on the Superior Student said that colleges often fail to give the gifted student adequate opportunity. This has come about because of the erroneous assumption that the gifted can take care of themselves and that special provision for them is undemocratic. The gifted student should be identified early and follow an honors program through four college years, he said.

The question of teacher capability also came under review. Dr. L. Bryce Andersen, Assistant Professor of Chemical Engineering at Lehigh Univ declared that it is now time to "rely more on the science of teaching in the teaching of science." Too many engineering teachers know what to teach but have no idea how to teach it.

Otto E. Lancaster, George Westinghouse Professor of Engineering Education at Pennsylvania State Univ called for more study of teaching methods to assure that communication between teacher and student is taking place. He asked engineering educators whether there are conceivable instruments which should be employed in the classroom that would help the educator tune in on the frequency of the thoughts of each of the students in his class.

The social responsibility of the engineer was another question before the forum. Dr. Dael Wolfle, executive officer of the American Association for the Advancement of Science, said that scientists and engineers should take greater responsibility for the social problems they have helped create. He called on his audience to contribute to planning the social and economic framework in which tomorrow's engineers will work.

Very effective aid to underdeveloped countries could be provided by through shipping the contents of used car lots and a set of tools to prospective engineers in Asia, according to Professor J. Raymond Pearson of the Univ of Michigan. These youngsters are deficient in the know-how the American boy gets from tearing down and reconstructing his "jalopy." This puts the foreigner under a serious handicap when he enrolls in an engineering course here. ■

Hydraulic Fluid Developed for X-15

SAN FRANCISCO—A synthesized silicate ester hydraulic fluid that takes up where petroleum-based fluids leave off is planned for use on the manned rocket ship X-15. The new hydraulic fluid is a joint development of the California Research Corp and the Air Force, and is currently marketed by Oronite Chemical Co.

Called the 8515 Fluid, it will perform at temperatures in excess of 450 F and below −65 F. Internal temperatures of the X-15 are expected to exceed 450 F. Ordinary fluid tend to sludge at about 250 F.

The fluid is designed to have small changes in viscosity over a wide temperature range to avoid pump failures or system sluggishness. Low vapor pressure is another design requirement to avert vapor pockets and excessive evaporation which leads to lubricating problems.

This base stock of the new fluid is a special type of silicate ester with superior viscosity-temperature properties. Thickening agents further improve viscosity. Other principal ingredients include oxidation and corrosion inhibitors, and swelling agents to prevent leakage around gaskets and seals at extreme temperatures. ■

COMING EVENTS

AUGUST

4-5 . . . . American Astronautical Society, 2nd Annual Western Regional Meeting, Ambassador Hotel, Los Angeles.

4-6 . . . . Society of Photographic Instrumentation Engineers, Annual Convention and Exhiborama, Ambassador Hotel, Los Angeles, Calif.

18-21 . . . . Western Electronic Show and Convention, Cow Palace, San Francisco, Calif.

23-25 . . . . American Society for Metals, Eastern New York Conference on Fracture of Engineering Materials, Rensselaer Polytechnic Institute, Troy, N. Y.

SEPTEMBER

10-11 . . . . Society of the Plastics Industry, Midwest Section Conference, French Lick Sheraton Hotel, French Lick, Ind.

20-25 . . . . Instrument Society of America, 14th Annual Conference and Exhibit, Chicago Amphitheater and downtown hotels, Chicago, Ill.

21-22 . . . . Steel Founders' Society of America, 57th Fall Meeting, The Homestead, Hot Springs, Va.

23-25 . . . . Office Equipment Manufacturers Institute, Business Equipment Exposition, National Guard Armory, Washington, D. C.

23-25 . . . . Institute of Radio Engineers, American Institute of Electrical Engineers, 4th Annual Special Technical Conference on Non-linear Magnetics and Magnetic Amplifiers, Shoreham Hotel, Washington, D. C.

28-Oct 1 . . . . American Welding Society, Fall Meeting, Sheraton-Cadillac Hotel, Detroit, Mich.

OCTOBER

1-2 . . . . Society of the Plastics Industry, Fifteenth New England Section Conference, Wentworth-by-the-Sea, Portsmouth, N. H.

5-7 . . . . Institute of Radio Engineers, Fifth National Communications Symposium, Hotel Utica, Utica, N. Y.

GM's Gas-fed Trucks Engines Slated in V-6, V-12 Lots

DETROIT—Radically new gasoline-fed truck engines (*PE*—May 18, p 25) will be produced by GMC Division of GM in V-6 and V-12 cylinder configurations. The bore and stroke multiple will range up to 702 in. ■

See $25-million R&D Need for Electrical Relay Industry

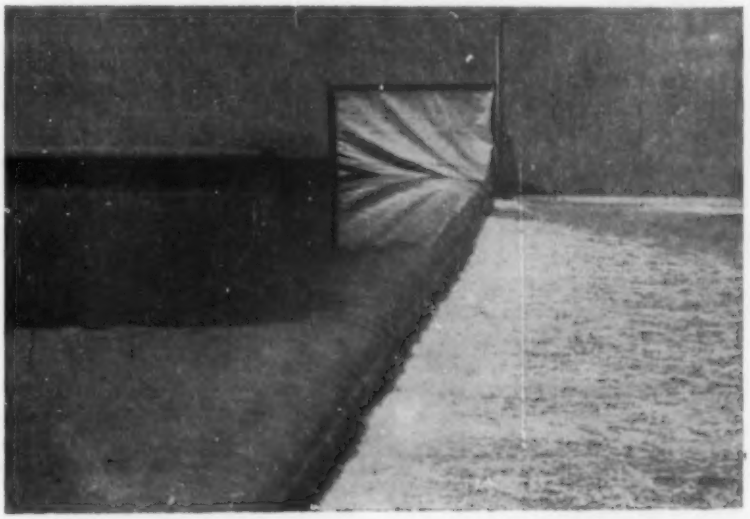
NEW YORK—The electrical relay industry will have to spend $25 million or more in the next 10 years on research and test equipment to meet the need for extremely high reliability in missiles, space craft, computers and other complex electronic devices, according to Edward Bachorik, Allied Control Co, Inc. The estimate was given as a conservative measure of increasing relay reliability costs at a High Reliability Seminar, here.

To maintain a high order of reliability, 100% environmental screening tests are used. According to Ralph Ferry, director of test engineering at Allied Control, the endurance tests determine the stability of the relay as well as its critical aspects, and include repeated measurements of electrical and physical characteristics. The environmental test sequence includes tests at high, low and room temperatures, humidity, shock in six directions, vibration in three planes, acceleration in six planes, tumbling, terminal pull, temperature cycling, and extended life testing at rated contact load at maximum ambient.

REQUIRES CAREFUL HANDLING

Relay reliability can be quickly destroyed by mishandling in user's plant during assembly into the product, reports Kirby Austin, director of research for Allied Control. A survey shows that a typical relay is handled 3 to 12 times before it is mounted in subassembly chassis—mistreatment is likely. Austin points out that over 1000 g's force are apt to result from a short drop onto a steel or concrete floor, and that this far exceeds designed shock tolerance. Typical damage: ruined hermetic seal, altered air-gap, change in contact force. And

Collapsible Nylon Dam Controls River



Water-inflated nylon dam diverts Los Angeles river water onto adjacent spreading ground for later recovery by pumping. New dam automatically deflates when a predetermined height of flood water is reached and prevents river from overflowing its banks during seasonal rains. Tube is bolted to the sides of the concrete-lined channel; when fully inflated stands 5'8" high, measures 30' in circumference, is 130' long. Portable device weighs 7000 lb uninflated and tube can be emptied in 12 min, reinflated within 25 min. Tubing material is neoprene coated, square woven nylon fabric covered with a special aluminum paint. Tubing fabrication costs about $7000. Firestone Rubber Co, fabricators of the tubing, and inventor N M Imbertson of the LA dept of Water and Power, say the operational life is from six to 10 yr.

overcurrent or overvoltage during customer tests can damage contacts.

Misapplication of relays is also a serious cause of unreliability. For example, a permanent magnet placed too near a sensitive electromagnetic relay can alter the operating point. Other errors can be: environment proves more severe than assumed; circuit loadings through the relay contacts get reversed; product tests procedures are not up-to-date. Good reliability is a joint responsibility, and here are Austin's suggestions to achieve it: use shipping containers designed to double as assembly trays; be sure that test instruments—including indicating lamps—have cold inrush currents that never exceed the rated current of the relay; plan meetings between relay manufacturer and user during product design stage to discuss every circuit and every contact of the relay.

RELAYS GET BETTER

Improved relay design over the past 10 years is traceable to MIL-R-5757, which is in its fourth revision. Early sealed relays, for example, were large and heavy, said Edward Hoell, design engineer at Allied Controls. Continued research has now made it standard practice to build the switching unit directly on the terminal header, and in many cases the housing is used as part of the magnetic circuit of the motor section. By these techniques, and through the use of more compact and efficient magnetic design, there has been a volume reduction in today's micro-miniature relays of approximately 15 to 1.

Miniaturization and improved performance are not incompatible, continued Hoell. Within the past decade the vibration resistance of relays has been increased from 10 g's in a frequency range from 10 to 55 cycles to 30 g's up to 2000 cycles. Standard operating ambient temperatures now extend from −65 to 125 C, and a number of new relays are being made for operation at 200 C. Shock resistance on most current relays is up to 100 g's, and operating characteristics are stable within a few per cent under constant acceleration up to 60 g's.

Present multi-pole relay designs afford the engineer a switching device capable of handling circuit currents in a range of 5-million to one, from 5 amp to a microamp, concluded Hoell. All circuits are mutually isolated and also isolated in turn from the coil actuating circuit. It is a self-contained unit that operates over a wide range temperature and under extreme conditions of shock and vibration.

TREND TO MINIATURIZATION

Current trends in relay design are in the direction of further miniaturization, incremental spacing of terminals, adaptability to printed circuits and automation. At the moment development programs are proceeding to push operating temperature limits to 300 C and beyond. Most recently radiation resistance has been included in the selection of materials for relays with a high order of reliability. ■

Soviet Designers Are Called Goldbrickers

Moscow—Soviet design organizations are harboring ineffective engineers in high posts, according to the influential state newspaper *Izvestia*, which cited one of Russia's primary research institutes, ENIMS, USSR machine-tool organization, as an example in a vitriolic 2000-word blast.

Izvestia said educated goldbrickers, after earning university degrees, are "taking cover in the alleged complexity of the problems they are supposed to solve," producing naught and at the same time blocking advancement of younger, more talented men.

The newspaper said there are two ways of rectifying the situation: Either put experimental work on a cost-accounting basis, or have Communist Party units "remove all who are simply husks." The article left it to the scientists to decide on the best way to "rid themselves of those who are merely husks."

Izvestia named two offenders on the staff of ENIMS (Experimental Machine Building Institute). One of them, Valerian Petrovich, was accused of treating his work "merely as a livelihood", and of being a "Babbitt in science." Here's his case:

Valerian Petrovich, about 45, finished a higher technical school education, then worked for two years as shop technician at an engineering foundry. After that, he prepared a dissertation, won a degree and, for the last five years, has been on the ENIMS staff. "These five years," *Izvestia* says, "He has spent on a purely theoretical theme and the period has been fruitless. There has been no gleam of novelty in his experiments, nothing that could interest foundry men."

This man is not a rare exception, *Izvestia* said. "There are also other self-styled 'scientists' who have not enriched science or production with even one bright idea and who are way behind the advanced people of the country."

It implied there also was trouble at Tsniitmash (Central Heavy Machinery Research Institute). It said none of its 150 masters of science or 12 PhD's have reported on their work in the past year.

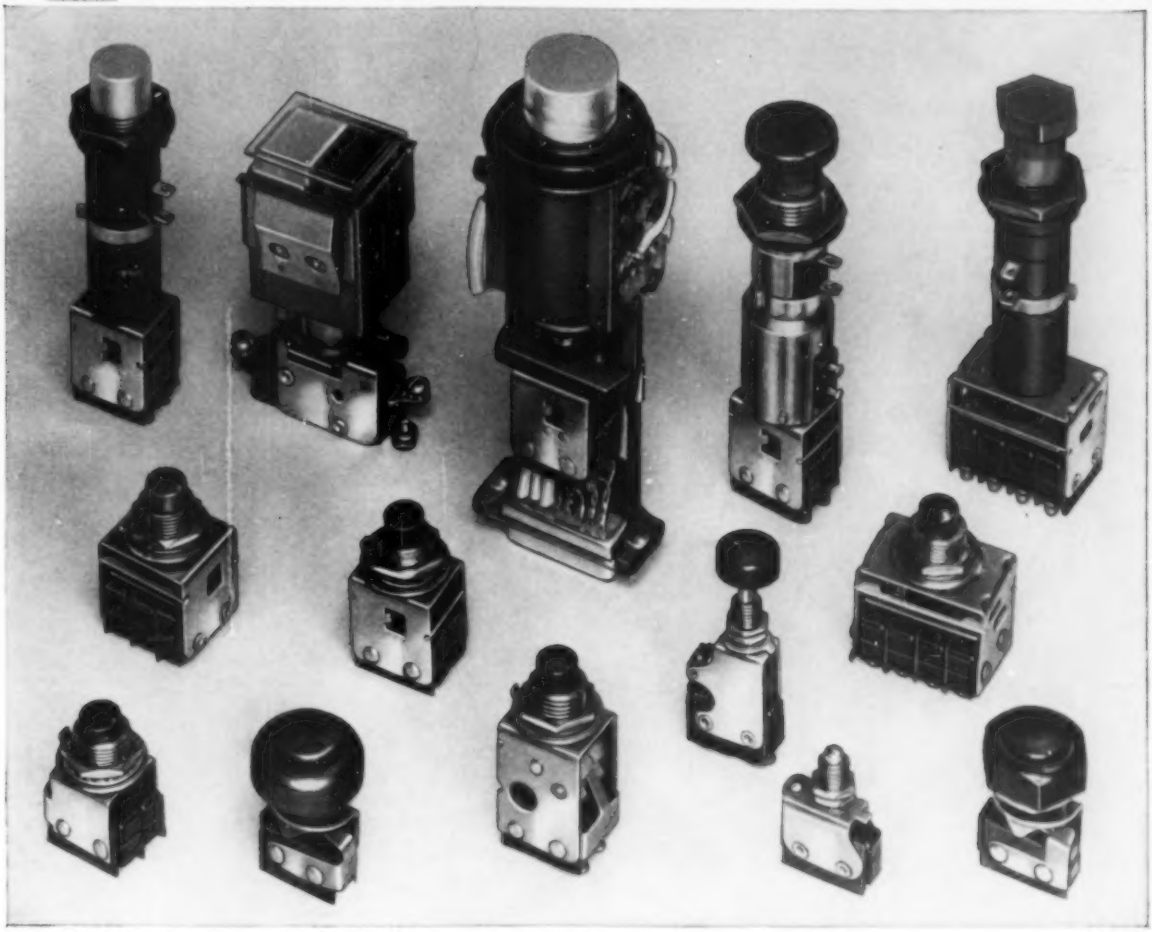
The newspaper complimented Tsniitmash, however, for design of a high-speed mill for the continual rolling of a steel band. It said some engineers at ENIMS have also done good work: an automatic gear-making line and some program-controlled machine tools were cited as examples. ■

British Mull Quality Control Issues

Buxton, England—Quality control in industry comes "too little and too late" according to leading British experts who gathered here for a joint conference of production and inspection engineers.

At conference sessions, participants called for earlier integration of inspection into the production cycle. A quality control program should be planned while product specifications are being drawn up, not tossed in afterwards. Machine-tool limitations should be determined when specifications are drawn, not discovered later. And sub contractors should be consulted before final plans are specified.

Systems for controlling men on the production line also came under intense fire. Some experts thought piece work—generally accepted here as an essential part of production life—encouraged machine operators to pass marginal work, unless they were paid for self-declared scrap. But, the experts said, paying a man for scrap is incompatible with the system. ■



Need pushbutton switches?

Here is a sampling of a very wide choice

These assemblies are typical of many different series of MICRO SWITCH pushbutton switches. Each series offers many variations of electrical and operating characteristics.

Operational characteristics include: momentary action, lock-down, alternate action, two-position alternate action, and magnetically held. Direct control of up to fourteen double-throw circuits is offered. Short and long button strokes can be provided. Sealed switches are available when protection is required from oil, water, sand, or salt spray. Special shock and vibration-resistant features are built into switches for rugged duty service. Switches with illuminated pushbutton display are available. These include switch devices with interchangeable modular indicator and pushbutton units.

Experienced engineering assistance to help you select the pushbutton switch best suited to your requirements is as near as your MICRO SWITCH branch. There is no obligation.

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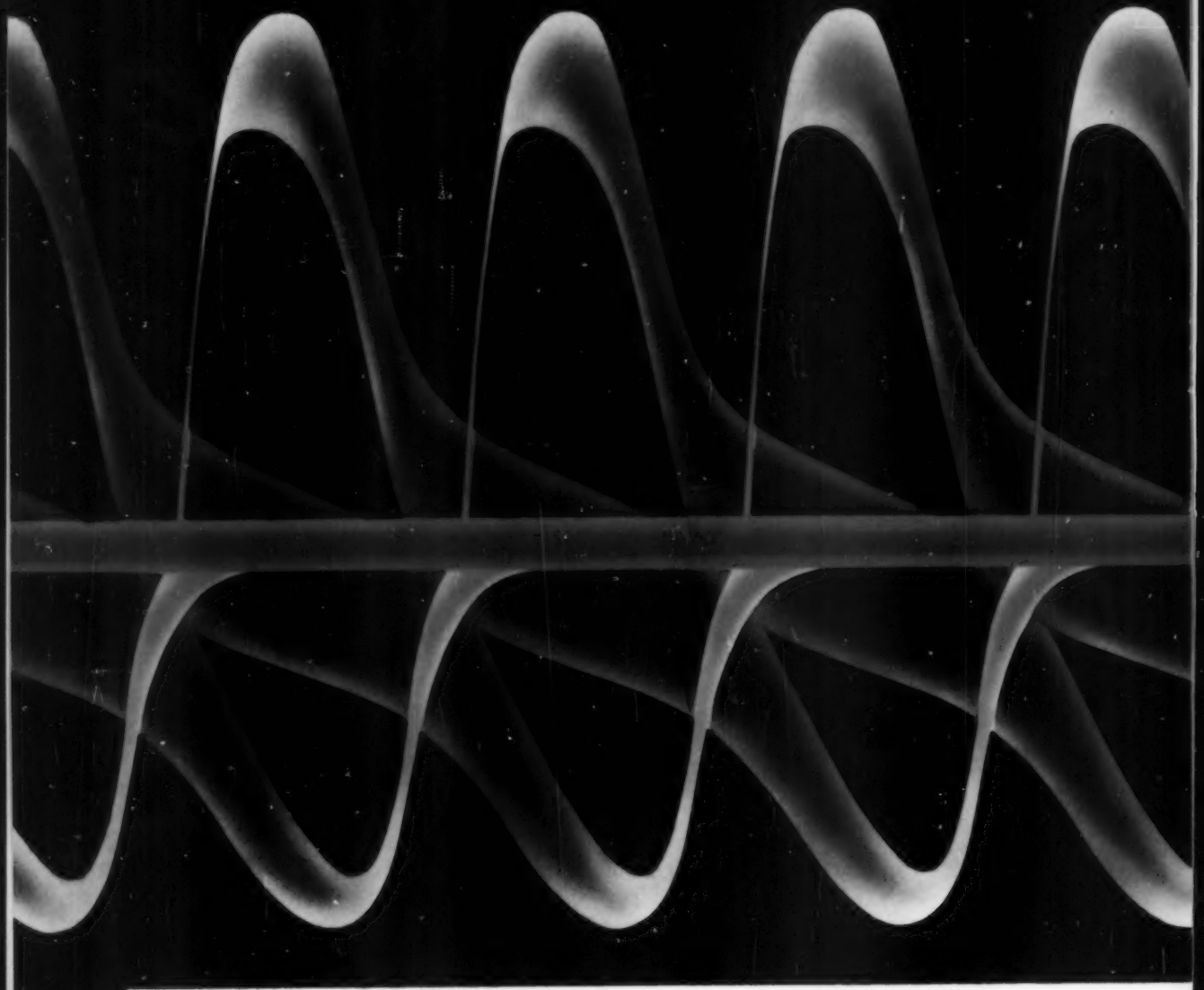


The cathode ray oscilloscope is one of science's and industry's most perceptive instruments for determining uniformity of operation. The pattern reproduced here is a harmonically modulated sine wave of exact uniformity.

Uniformity is Malleable

Just as the input of an oscilloscope can be controlled to produce repetitive patterns, so can consistently uniform metal parts be produced with Malleable iron because of modern, scientific controls. The unique method by which all Malleable castings are made and the exacting techniques employed by Malleable foundries assure Malleable users of castings that are uniform, part after part, regardless of size or shape. This uniformity, combined with unparalleled physical and mechanical properties, ideally suits Malleable castings for modern America's quality products.

For information or service, call on one of the progressive firms that identify themselves with this symbol—

MEMBER

MALLEABLE

CASTINGS COUNCIL

If you wish, you may inquire direct to the Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio, for information.

Better Products at Lower Cost Result From Malleable Uniformity Controls

Uniform quality — whether for five or five million pieces — is essential to maintain product quality and increase manufacturing efficiency. With accelerating frequency, Malleable castings contribute their unique uniformity in critical applications where durable, reliable components are necessary.

Key to Uniformity is Control

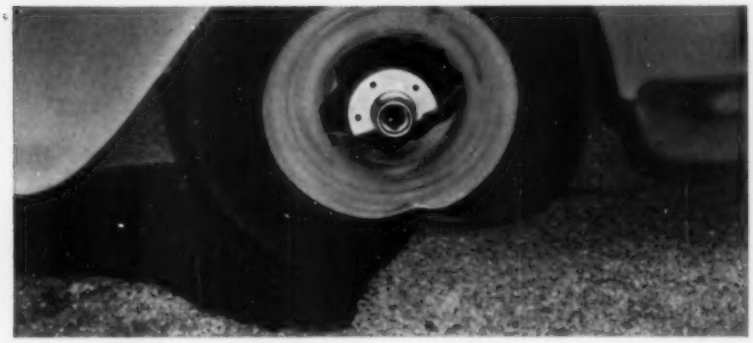
Malleable iron is produced under closely controlled manufacturing techniques. From charge composition and molding sand properties, through final inspection, every critical factor is held constant by using the most modern techniques of metal analysis, process control and inspection.

Internal Uniformity

This versatile engineering material is achieved through converting the base white iron into tough Malleable iron by a controlled heat treating process. Malleable's internal structure exhibits excellent uniformity, an important factor in assuring the dependable performance of intricately designed components.

External Uniformity

Fundamental to the casting process is the ability to produce a given shape, time after time, in either small or large quantities. Metal can be placed exactly where it is needed . . . eliminated where it is not. Good design — achieved through close cooperation between the customer and the foundry — can assure the necessary tolerances and the lowest possible finished part cost. Modern techniques of production and inspection are used to insure top quality, dimensionally accurate castings.



The life of every motorist rides in complete safety on Malleable wheel hubs of unerring uniformity.

Uniformity Proven by Use

The final test of any part is how well it stands up in actual service. Under continuous cyclic and shock loading, the millions of Malleable wheel hubs, which are in service on the front end of every American-made car, have compiled an enviable record of proven uniformity. Another dramatic example of Malleable's uniformity is proved in the old adage "A chain is only as strong as its weakest link." Miles of Malleable chain, carrying tremendous loads year after year without failure, demonstrate the uniformity of every cast link.

New techniques for controlling every element of Malleable production are the result of intensive research done by Malleable foundries in their continuing search for ways to make Malleable even more versatile and indispensable to industry.

More Information Available

Your copy of *Data Unit 103—Uniformity* — is available from any member of the Malleable Castings Council. If you prefer, write direct to Malleable Castings Council, Union Commerce Building, Cleveland 14, Ohio.

These companies are members of the

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CONNECTICUT
Connecticut Mall. Castings Co., New Haven 6
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New Haven Malleable Iron Co., New Haven 4

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ILLINOIS
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Moline Malleable Iron Co., St. Charles
National Mall. and Steel Castings Co., Cicero 50
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Frazer & Jones Company Division Eastern Malleable Iron Co., Solvay
Oriskany Malleable Iron Co., Inc., Oriskany
Westmoreland Mall. Iron Co., Westmoreland

OHIO
American Malleable Castings Co., Marion
Canton Malleable Iron Co., Canton 5
Central Fdry. Div., Gen. Motors, Defiance
Dayton Mall. Iron Co., Ironton Div., Ironton
Dayton Mall. Iron Co., Ohio Mall. Div., Columbus 16
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National Mall. and Steel Castings Co., Cleveland 6

PENNSYLVANIA
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Erie Malleable Iron Co., Erie
Lancaster Malleable Castings Co., Lancaster
Lehigh Foundries Company, Easton
Meadville Malleable Iron Co., Meadville
Pennsylvania Malleable Iron Corp., Lancaster

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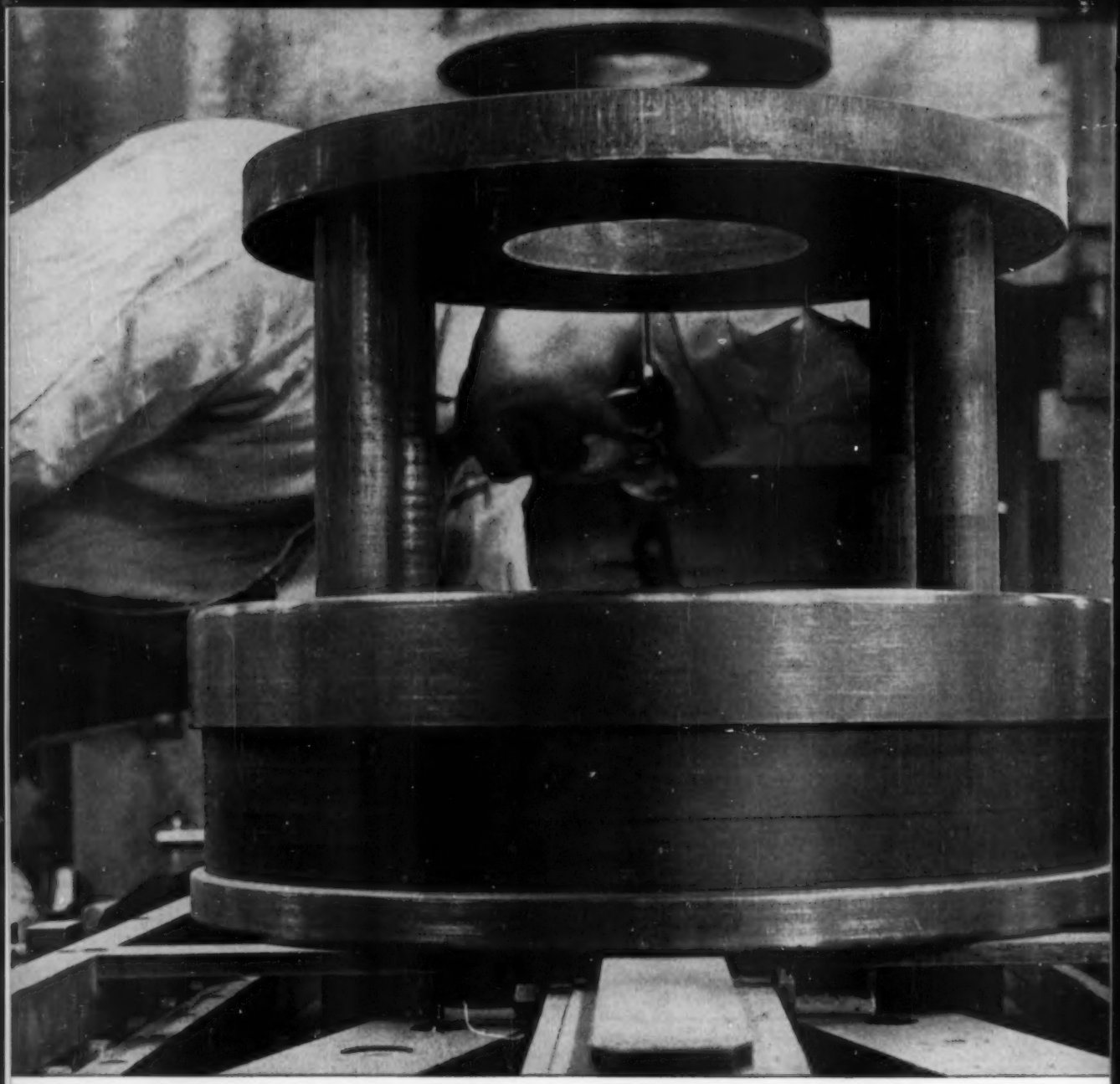
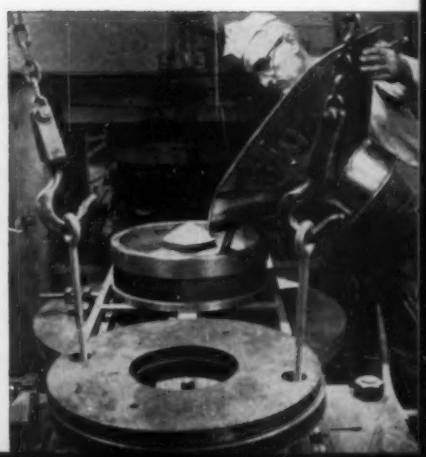
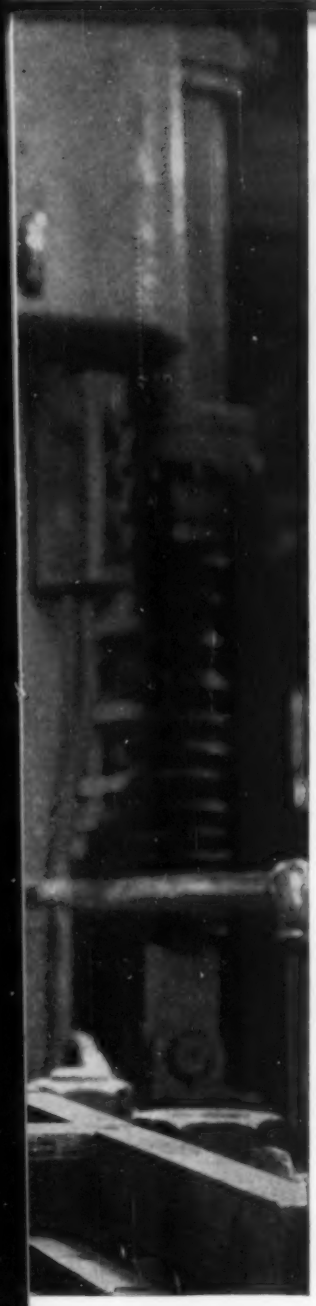
West Virginia Mall. Iron Co., Point Pleasant

WISCONSIN
Badger Malleable & Mfg. Co., S. Milwaukee
Belle City Malleable Iron Co., Racine
Chain Belt Company, Milwaukee 1
Federal Malleable Company, West Allis 14
Kirsh Foundry Inc., Beaver Dam
Lakeside Malleable Castings Co., Racine
Milwaukee Malleable & Grey Iron Works, Milwaukee 46







Here's a tough old squeezer that won't wear out

The donut-shaped steel disc in the main illustration is the mold plate used in a large hydraulic press. Under 2,000 tons of pressure, it squeezes an abrasive mixture in a mold to make grinding wheels. It's a tough job, and Waltham Grinding Wheel Company had to replace these discs every few months because they wore down and became unbalanced. Replacements were expensive and they wasted production time.

Finally, Waltham tried a plate made of USS "T-1" Steel. It has been used for more than a year now, and Waltham engineers say it will last indefinitely.

"T-1" constructional alloy steel has a minimum yield strength of 100,000 psi. It is exceptionally tough and resistant to abrasion—can be furnished heat treated to a minimum hardness of 321 Brinell. Compared to carbon steel, it has four times more resistance to atmospheric corrosion. In spite of its strength and toughness, "T-1" Steel can be formed, machined and welded. And because of its strength, it can be used in lighter gages, reducing weight as much as ⅔, depending on the application.

If you would like to have complete information about "T-1" Steel, write for our book "USS 'T-1' Steel," United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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USS

United States Steel Corporation—Pittsburgh
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Tennessee Coal & Iron—Fairfield, Alabama
United States Steel Supply—Steel Service Centers
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United States Steel

BEARING BRIEFINGS

One in a series of technical reports by Bower

ROLLER GUIDANCE– VITAL FACTOR IN BEARING LIFE

Roller guidance has been established by the Anti-Friction Bearing Manufacturers Association as a major rating factor for roller bearings. There is a direct relationship between this factor and the life and capacity of a cylindrical roller bearing under load.

Figure 1 illustrates the results of a loose fit between a roller and the guiding ribs of the raceway. Because of lack of guidance by the ribs, the roller is free to skew and skid under load. Such a condition invariably leads to early bearing failure.

To achieve close roller fit and proper roller guidance, Bower precision grinds each bearing race on specially designed centerless grinders. In this operation, Bower positions the integral raceway ribs *from the theoretical centerline of the bearing*. This method produces bearings with high dimensional accuracy and perfect symmetry.

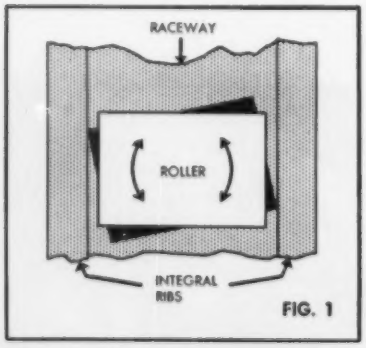
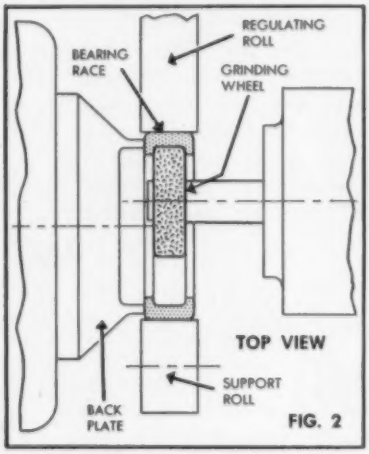
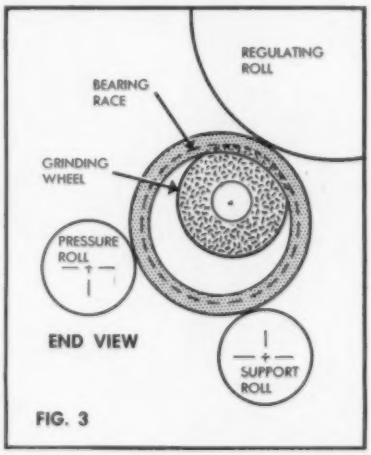


Fig. 1. Loose fit in raceway means poor roller guidance. Roller can skew and skid under load.

In addition, the close tolerances held in grinding the roller track and integral guiding ribs give Bower cylindrical roller bearings the ability to *take thrust in any direction*. A Bower cylindrical roller bearing has thrust capacity of from 10-15% of its rated radial capacity!



Figures 2 and 3 diagram the centerless grinding method used to finish Bower raceways. Use of this technique assures not only optimum roller guidance and maximum bearing life, but also virtually eliminates bearing runout. BEARING SYMMETRY WHICH RESULTS FROM THIS TECHNIQUE PERMITS ACCURATE SHAFT LOCATION REGARDLESS OF HOW THE OUTER RACE AND ROLLER ASSEMBLY ARE INSTALLED. IT COMPLETELY ELIMINATES THE POSSIBILITY OF IMPROPER INSTALLATION.

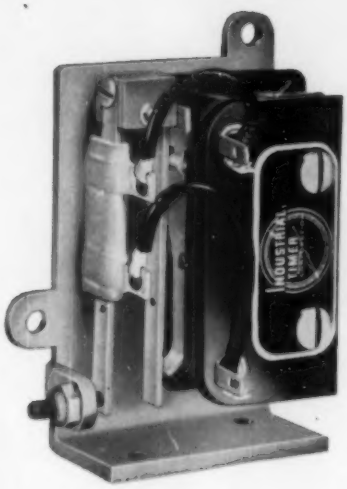


★ ★ ★ ★

Whatever your bearing needs, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN



NEW! MINIATURE THERMAL TIME DELAY SWITCH

10-20 Amp. Capacity—SNAP ACTION

The new Series TH Timer makes accurate switching control of high current applications *practical* and *economical* for the first time! No more bulky, costly thermal switch and relay combinations . . . no more teasing of load contacts in electro-mechanical circuits from slow make-and-break. The new Series TH Timer's SNAP ACTION contacts give *fast, positive* switching of loads *up to 20 amperes.*

There's a wide choice of contacts, too: SPDT, DPDT, Double Break, Magnetic Blowout DC and others to match your needs.

This new, compact timer automatically compensates for ambient temperature changes, by using two parallel bi-metal strips. Longer life comes from the rugged, totally enclosed cast ceramic heater. And you can adjust your time cycle easily with a single screw.

Available in time cycles from 15 seconds to 2 minutes, the new Series TH Timers are the low-cost answer to switching in air conditioning, refrigeration, exhaust and heater controls, computers, lighting, and a host of other applications.

For complete information, write today for Bulletin #900.

These new developments are just two recent items added to our ever growing line of industrial timing devices which now exceeds 1,700 controls. If you would like more information about the line, drop us a note requesting our general catalogue.

NEW! SIMPLIFIED PUNCHED CARD PROGRAMMER

Direct Control from Programmer to Process!

Here's the simple, dependable method of applying true automatic control to most of your manufacturing and operational processes . . . *direct control* of up to 85 individual load circuits through as many as 30 separate functions . . . with permanent, convenient 5" x 9" Mylar* punched cards.

Operation from any switch closure makes this electro-mechanical card reader easily adaptable to a variety of control systems, including analog, digital, temperature, feed-back, photoelectric, time and many others. Already in use for a wide variety of industrial and military applications, these flexible units are easily modified to meet your particular requirement.

For more information, write for Bulletin #100.

AFFILIATE: LINE ELECTRIC COMPANY

* Reg. T.M. du Pont

Timers that Control the Pulse Beat of Industry

INDUSTRIAL TIMER CORPORATION

1415 McCARTER HIGHWAY, NEWARK 4, N. J.

DOW | MAGNESIUM

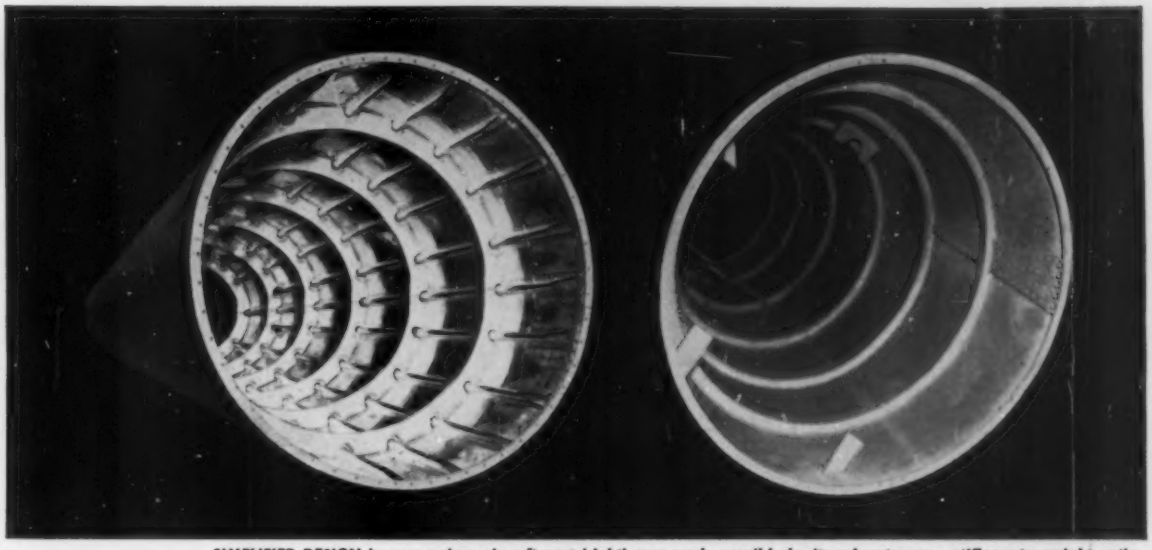
LIGHTWEIGHT DESIGNS

save more than weight

Designers reap a rich harvest of additional benefits as a result of lightness when they use magnesium. Bonuses such as more payload, simplified design, increased performance and reduced human exertion.

People who buy and use the luggage pictured above derive a very direct benefit from magnesium. As this lightweight luggage is made of magnesium, it saves human effort and fatigue. Also, the reduction of weight means more luggage can be carried without extra charge when traveling by air. Magnesium saves human exertion in other products, such as ladders, power tool housings and materials handling equipment.

Another example of the many savings and extra benefits that magnesium —and its resultant load lightening make possible for the designer is in the automotive field. One delivery truck unloads its last parcel and heads for the garage and the gas pump. Another, of identical size, goes on to deliver many



SIMPLIFIED DESIGN in magnesium aircraft part (right) was made possible by its advantageous stiffness-to-weight ratio.

more lbs. of merchandise. Why? The second truck is much lighter–its body is made entirely of magnesium alloy sheet, plate and extrusions. *Because* the second truck is lightweight, it can carry more payload. Or, it can carry the same payload as the first with less fuel, smaller tires and less wear and tear on the engine and transmission. Lighter trucks also save their owners money on license fees, insurance premiums and over-all maintenance.

An even more dramatic example is that of missile design. In one ballistic missile, the elimination of *one pound* of excess weight contributes approximately 18,000 feet of additional altitude and a comparable increase in range! This means vastly improved performance wherever magnesium can be substituted for heavier materials.

MAGNESIUM LIGHTNESS INCREASES STRENGTH, STIFFNESS

The designer who is seeking a stiff section can achieve it easily–and still save weight–with magnesium alloys. Magnesium weighs only 67% as much as aluminum, 25% as much as steel and zinc. A structure made of magnesium could be 8 times as stiff as the same part in steel if designed to equal weight. If equal stiffness is the design criterion, a magnesium section can weigh 62% less than steel and 25% less than aluminum.

Aircraft manufacturers have learned to exploit these facts to the fullest in conserving precious airborne weight. Critical parts such as wing and tail structures can be designed with more than adequate stiffness for high speed flying conditions. And, in addition to weight savings, magnesium helps provide a smooth aerodynamic surface and reduces "flutter" and "drag". Most important, the use of more rigid magnesium sections simplifies design by eliminating many of the stringers and stiffeners necessary with other materials.

★ ★ ★

WRITE TODAY for new brochure, "Magnesium Design". For your copy of this valuable reference for designers, contact the nearest Dow sales office or write to THE DOW CHEMICAL COMPANY, Midland, Michigan, Magnesium Products Sales Department 1342 DZ7-6.

22,000 r.p.m. HOUSEHOLD ITEM

This die cast vacuum cleaner fan must rotate at 22,000 r.p.m. and have low starting inertia as well as high centrifugal strength. Only magnesium was able to meet the requirements of this specific design. Casting tolerances are held so closely there is no need for balancing.

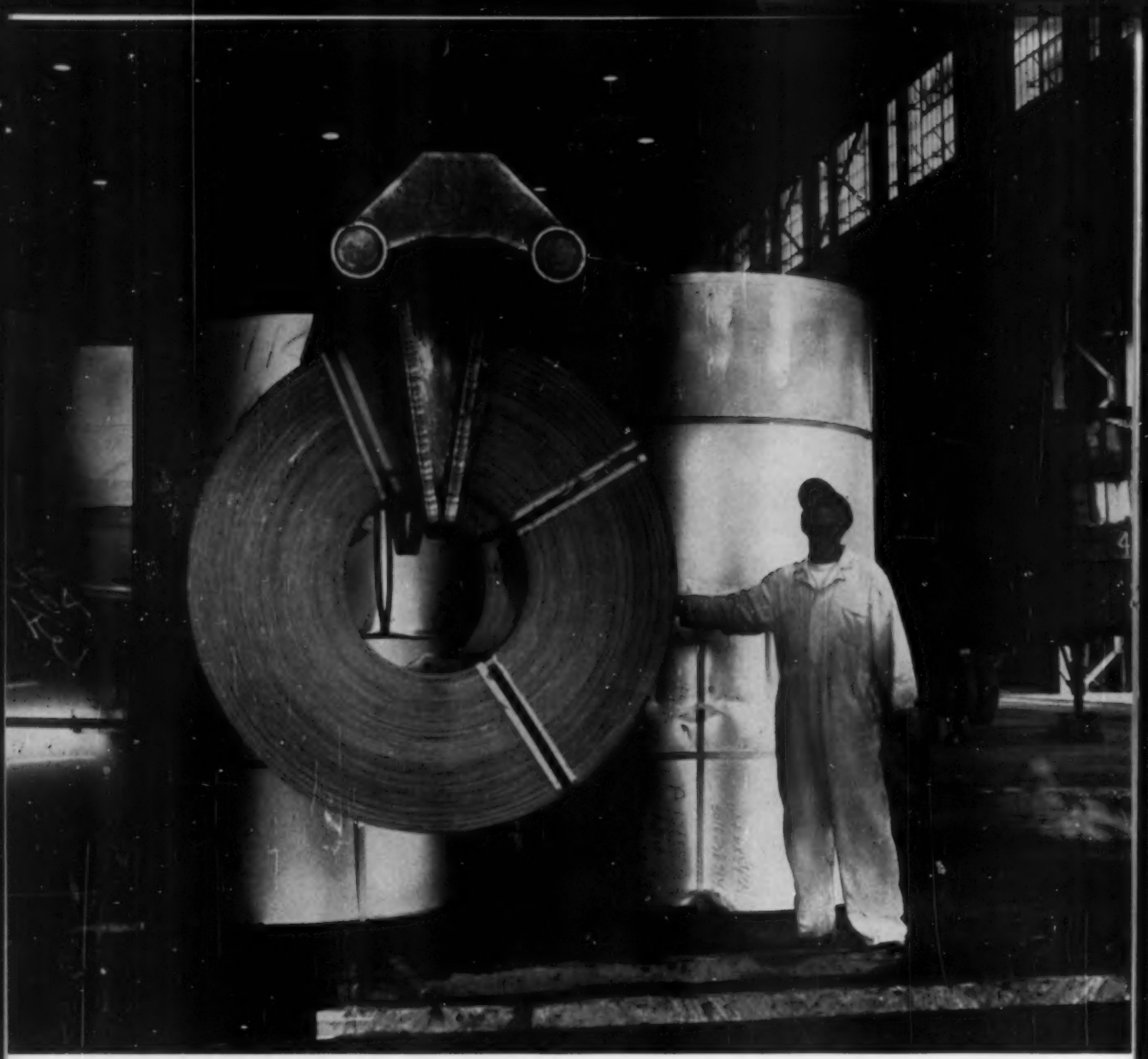
WORKER FATIGUE THWARTED

A prominent automotive manufacturer uses magnesium paint shields in spraying speedometer panels. The weight saving compared to previous shields resulted in less fatigue, higher efficiency for women employees. The excellent alkali resistance of magnesium permits easy removal of dried paint.

DOW PRODUCTION FACILITIES

The Dow Madison, Ill. mill rolls flat sheet and plate and coiled sheet. It also provides extrusions up to 30" circumscribing circle. The Dow Bay City plants produce high quality sand, permanent mold and die castings as well as lightweight magnesium fabricated assemblies. And, you get Dow experience and technical service in addition.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN



INSTANT STEEL

A CALL TO YOUR LOCAL STEEL DISTRIBUTOR ENDS IN-PLANT SHORTAGES FAST!

Emergency? Your steel service center can end it in a hurry with practically any amount, quality, size or shape of steel you may need. No more in-plant steel shortages—no more plant shutdowns—no more lost contracts.

Or you may choose to use his facilities, stocks and fast delivery service on a regular basis. Whatever your production needs, your local steel distributor is on hand ready to give instant service. All you have to do is phone.

Call him for any quantity of Weirkote continuous-process zinc-coated sheets, Weirzin electrolytic zinc-coated sheets, hot- or cold-rolled sheets or any type of steel you may need for any type of production job.

CIRCLE NO. 50 READER SERVICE CARD

WEIRTON STEEL COMPANY

WEIRTON STEEL COMPANY

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PERSPECTIVES

in design and development . . .

Trouble in Switzerland

Trouble with watches—not making them work, but selling them—has hit Switzerland, according to recent reports filtering through to the US. At the annual general meeting of Ebauches SA of Neuchatel (which is the leading concern in the Swiss watch industry, controlling 17 factories) company president Renggli probed the causes of recession in that industry during 1958, and related them to the fact that Swiss sales have always been sensitive to any disturbance in the world market. In 1958, Switzerland's watch business dropped 15% in export and 33% in total sales.

But Renggli blamed the US recession only in part for the export drop: "An important factor has been the closing of certain markets caused by throttling of imports, under the pretext of improving foreign exchange position, by countries who believe that they can develop their own watch industry with the aid of primitively trained excess labor. The most serious circumstance, however, is the strengthening of foreign competition."

Enter, the Red Bear

Whether Renggli was including the Russians in his statement about "primitively trained excess labor" or "strengthening of foreign competition," we don't know, but he should have.

Another report mentions that the Russian watch industry has reached a yearly production of 15 million units—almost half that of the Swiss industry. In 1952, a Swiss expert visiting Russia stated that the Russian watches had not even passed the point of mediocrity; in 1958, noteworthy progress was noticed. The fact is, Russian watches are already pushing their way into foreign markets. They were exhibited in Holland at the Utrecht Fair and it was obvious that they were priced below cost. Apparently the USSR is again using dumping methods to conquer foreign markets. Present efforts are aimed at winning the markets of India, Denmark, Sweden and Canada.

Switzerland Has a Plan

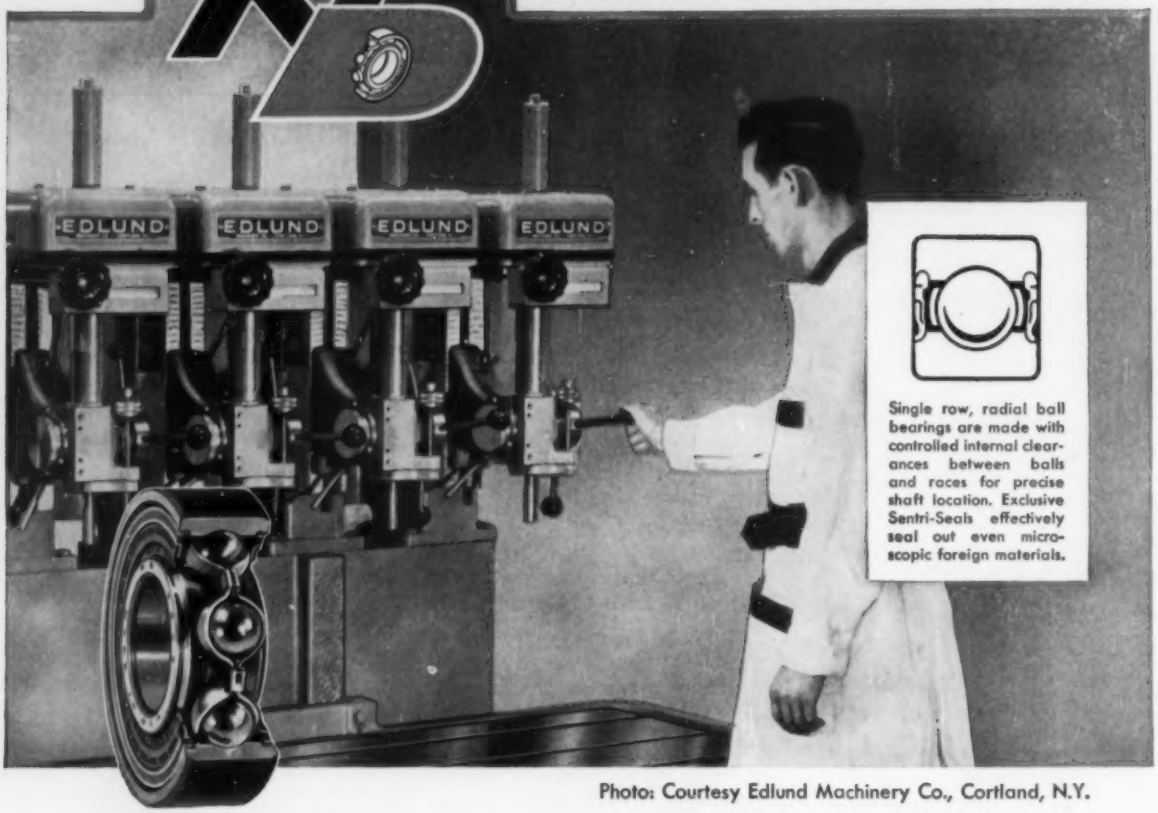
Switzerland's way out, believes Renggli, is to maintain a distinct lead in quality. In watch technique there are no better craftsmen, but in manufacturing methods Swiss industry will have to adapt itself to new concepts. To a great extent the organization is set up horizontally. There are independent special factories for components and semi-manufactured products. Though this is desirable in principle, in recent years this independence has been overdone and has retarded progress.

The existing federal controls in Switzerland should be relaxed to permit a vertical structure to develop, says an industry spokesman. If governmental control is not relaxed and the horizontal structure must be maintained, then care must be taken to export components and semi-manufactured goods only to those foreign companies who can be depended on for a careful further assembly and who do not undersell the Swiss watch manufacturers.

A reason for the 33% sales drop in '58 was the fact that in past years, sales of watch movements have gone up considerably in comparison to sales of complete watches. As the turnover in watches slowed down, the buyers of such movements turned to using up their stockpile, hence the unfavorable year for the Swiss.

—R E Abbott

CASE HISTORIES



Single row, radial ball bearings are made with controlled internal clearances between balls and races for precise shaft location. Exclusive Sentri-Seals effectively seal out even microscopic foreign materials.

Photo: Courtesy Edlund Machinery Co., Cortland, N.Y.

Ball Bearing Design Adds Efficiency... Cuts Relube Maintenance In Drilling Machine

CUSTOMER PROBLEM:

Tool manufacturer requires minimum maintenance ball bearing design for new high-speed multiple drilling machine.

SOLUTION:

N/D Sales Engineer, cooperating with company engineers, recommended New Departure ball bearings with exclusive Sentri-Seals in place of conventional open bearings. These ball bearings, sealed and lubricated for life, virtually eliminated bearing relubrication maintenance. In addition, these sealed bearings accounted for a savings in parts and assembly time by eliminating costly lubrication plumbing and fittings. What's more, the application has proved so successful, the customer has had other types of drilling machines redesigned to use New Departures.

If you're working on new machine designs, why not call on New Departure? There's probably an N/D *production* ball bearing that will help you, and, at a lower cost! For more information write Department P-7.

Replacement ball bearings available through United Motors System and its Independent Bearing Distributors

NEW DEPARTURE
DIVISION OF GENERAL MOTORS, BRISTOL, CONN.
NOTHING ROLLS LIKE A BALL

Product Engineering

HORIZONS

July 6, 1959

MODERN MESSAGE ~~to~~ from GARCIA

You've heard, of course, of the message to Garcia. It is still a popular catch phrase, has been ever since Elbert Hubbard sat down one evening and wrote an essay with the phrase as a title. It went millions of copies in a dozen languages—and was wrong from the start.

Lieut Andrew J Rowan did not take a message *to* Garcia; he was sent to bring one *from* the Cuban rebel leader—when Garcia would be ready to attack the Spaniards, in cooperation with invading Americans. Thus Hubbard is guilty of two errors: he "sent" the message in the wrong direction, and he failed to mention Rowan, who made the hazardous trip.

There are hundreds of other examples of faulty communication of information: Washington never chopped down a cherry tree; William Tell never challenged Gessler; the *Hesperus* was not wrecked on *Norman's Woe*; Paul Revere didn't get the message through (William Dawes did); Pershing did not say, "Lafayette, we are here." Jesus was not a carpenter, but a woodcarver.

These are all supposedly historical truths, but in each case the facts were adjusted, mis-remembered or fabricated by some writer who made the story famous. In none of these cases was the error vital—but it was an error just the same.

Thus it has ever been with our communications; thus it still is. Erroneous impressions are gotten by hearers or seers from the spoken or written word, even from drawings and photographs.

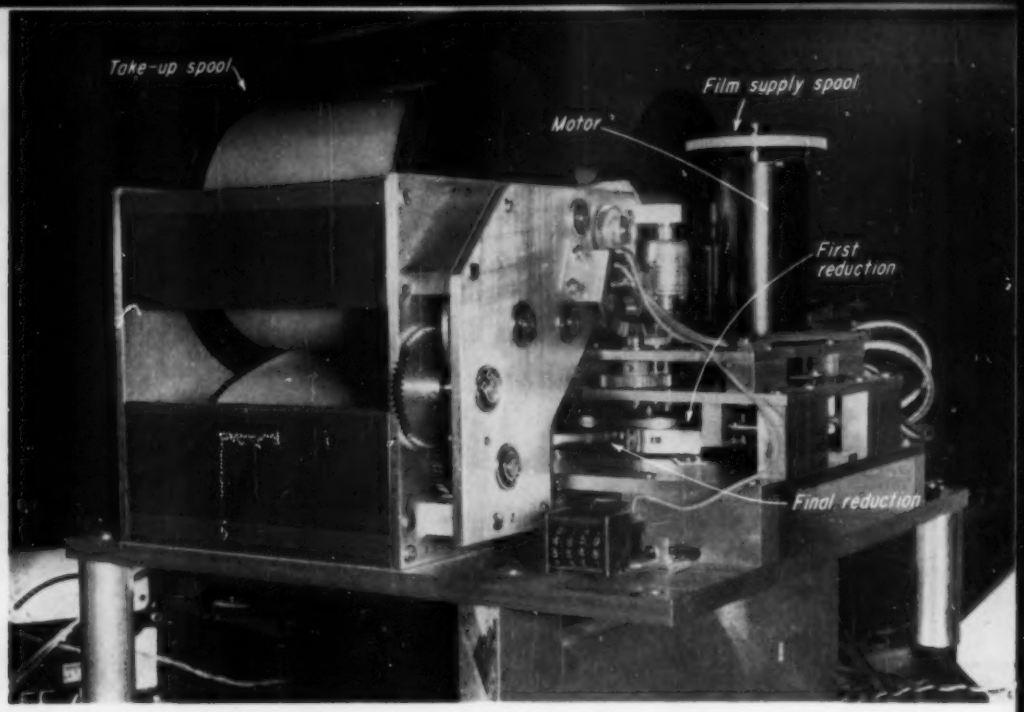
To err is, perhaps, basically human, as the old saw says, but need we do so much of it to prove our humanness? And need we accept so naively so many obvious ones? Or, worse still, make so many in conveying facts, thoughts or impressions to others?

The engineer tries hard to avoid errors—witness his continual addition of *normally*, *generally*, *usually* and like qualifiers to any statement incorporating a shred of doubt, or even a potential shred. He tries to supply, or imply, the conditions under which a given assumption is made. He checks pictures, loads drawings with detail.

These steps to assure accuracy may actually promote inaccuracy in other minds. They may suggest a potential problem where none exists, reduce confidence or acceptance when they should not. They may introduce questions about the worth of the job or the competence of the man. They may instill a bland confidence in the recipient of the data so he follows the modern practice of assuming that all the thinking has been done for him.

The essential formula in communication is a very old one: "When in Rome, do as the Romans do." Use the terminology of the recipient. Tell him what he needs to know; nothing more. The essence of good communication is to know more than you tell, not to tell more than you know; not to hazard a guess, but also not to bewilder with excessive detail. And all this must be done in the language of the hearer or reader—or he will make faulty assumptions, as so many of us have done about the message *from* Garcia.

K. Langeman



Rubberless friction drive in breadboard model of high-resolution camera.

FRICTION DRIVE features SPRING-LOADED IDLERS

No need for rubber rollers—the floating idlers give proper pressure between steel shafts for vibrationless drive. The authors develop torque and stress equations, and show how to apply them to a film drive.

J KAPLAN, *senior project engineer*
D BEAUMONT, *product designer*
Fairchild Camera & Instrument Corp
Syosset, NY

The usual rubber rollers are absent in this novel friction drive. Instead, there are spring-loaded idlers that permit making all parts from hardened steel. Like other friction drives, this arrangement transmits torque much smoother than a gear drive can. But without rubber, which tends to creep, it provides a well-defined transmission ratio.

The floating idlers are loaded against the shafts by a spring-and-lever arrangement and furnish proper pressure between the rolling elements. The idlers also obviate the need for a high degree of accuracy when locating the shaft centerlines.

Like other friction drives, this one is equivalent to a gear drive without teeth. But here, power from the input shaft rotates an idler (or pair of idlers) which, in turn, rotates an output disk. This disk is pinned to the output shaft or made an integral part of it. Speed ratio between the shafts is inversely proportional to ratio between diameters of output disk and input shaft.

As with gears, the output can drive a secondary system for still higher speed-reduction. This is done, for example, in the breadboard model (shown above) of the film-magazine drive for Fairchild Camera and Instrument Company's high-resolution camera.

Whether to use one or two idlers between input and output shaft depends on the application. Paired idlers will obviously double the torque transmission capacity for the same maximum contact stress of a single idler. Also, a judicious location of the axes of the two idlers can eliminate the reaction due to spring loading on the bearings—of particular value when transmitted motion is from shafts mounted in bearings not designed to withstand large radial loads.

The new friction drive can produce an output torque

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of several in.-lb while retaining these other advantages:

- Motion is smooth and free from jitter.
- There is a complete absence of backlash.
- Transmission efficiency is high.
- The drive can be designed to give large speed reductions in a single pass.

If the drive must operate under conditions of high contact stresses between its elements, careful consideration should be given to material, finish, alignment and concentricities. The rolling parts should be made of hardened steel; surfaces which are in rolling contact should have a good finish; input, output and idler shafts should be parallel and aligned axially. Where a pair of idlers is employed, eccentricities of the rolling surfaces should be held to minimum—such variations will result in slightly different surface speeds of the disk. Since the output disk is rigid, either one, or both, of the idlers must slip and this in time will produce wear of the rolling surfaces.

DESIGN EQUATIONS

For simplification, centers of input and output shafts are laid out in line with the pivot point of the crank arm. Distance between axes of the input and output shafts equals the sum of the radii of the driving shaft and the driven disk, and the clearance between them. For the double-idler arrangement, axes of the idlers and axis of the input shaft are made coplanar, so that the resulting reaction on the input-shaft bearings is zero. Reactions on the crank-arm pivot can also be eliminated by making its axis coplanar with the idler-link pivot axes.

Design procedure is similar to that followed with gears. Generally, one should know:

(1) Maximum output torque that must be produced.

(2) Speed ratio between input and output.

(3) Over-all size of the unit. For example, should the disk diameters for a ratio of 10 be about 10 in. and 1 in., or 2.5 in. and 0.25 in.

(4) Material to be employed, and the coefficient of friction between surfaces. If the coefficient ranges between two extremes, smallest value should be used to be on the safe side.

Knowing these values, the following equations will determine the link dimensions, required spring loading, and resulting surface stresses.

Center distance d (see diagram next page) between input and output shafts is:

$$d = \sqrt{(r_o + r_d)^2 - (r_i + r_d)^2} \qquad (1)$$

The output torque that could be transmitted through one idler is: $T_o = \mu N r_o$ (2)

The maximum permissible output torque is determined by the smaller μN product of the two reaction points of the idler (using the smallest predicted value for μ). The minimum resultant force R, necessary to produce a given output torque capacity, is obtained when μN is equal at both reaction points. Because the coefficients of friction at both contact points can be considered the same, the reactions must also be equal to produce the optimum conditions described in the previous statement. Direction of the external force which is to produce equal reactions, N, is along the angle bisector R of angle θ. Inasmuch as the idler link transmits the external load, direction of the idler-link axis must coincide with direction of the external load.

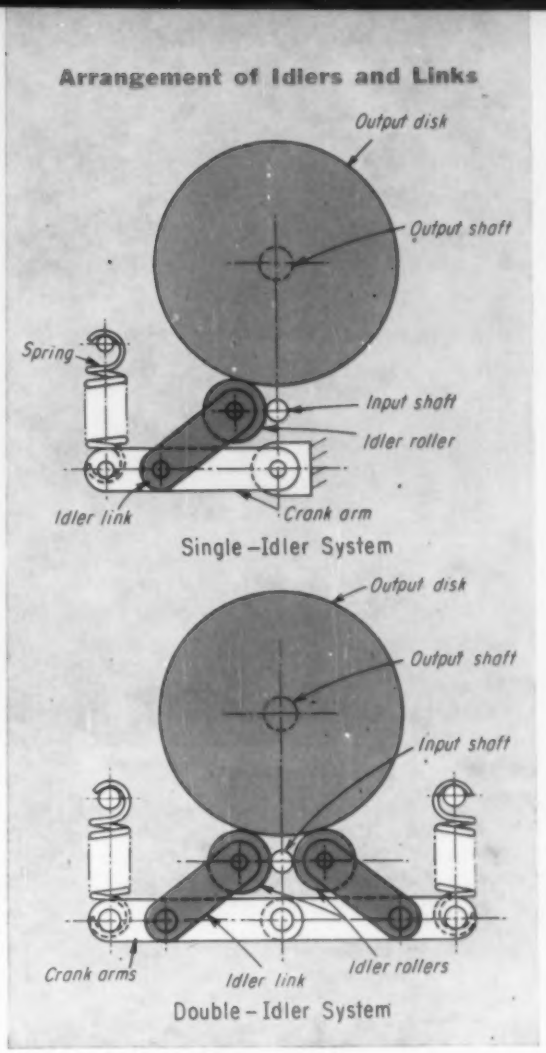
The small force diagram in the sketch on next page shows that load on the bearings of this idler is

$$\text{Cos}\,\frac{\theta}{2} = \frac{1}{2}\,R/N$$

or

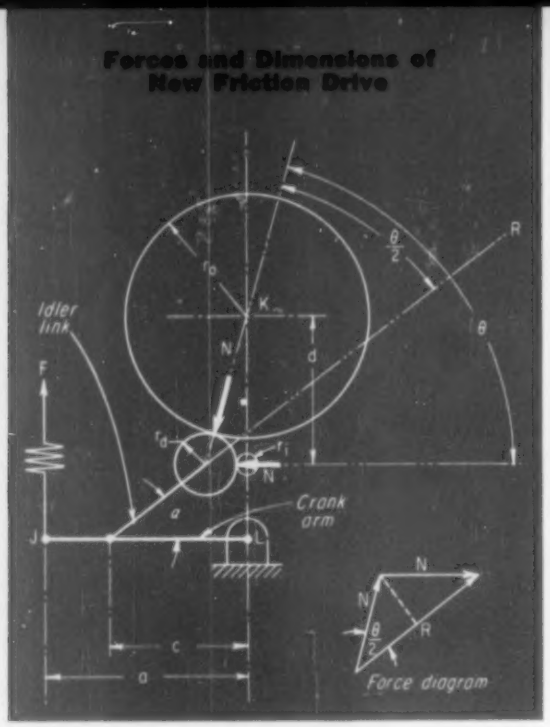
$$R = 2N \cos\frac{\theta}{2} \qquad (3)$$

By taking moments around point L, the spring force acting on the crank arm, which is necessary to produce



More to Come

Friction disks recently replaced gears in a planetary drive developed by Pratt and Whitney. Success of the design depended on a novel method of preloading the planets to automatically compensate for wear on the rollers. This necessitated the derivation of special design equations which will be published, with sample calculations, in a forthcoming issue.



force R is:

$$F = \frac{Rc \sin \alpha}{a} \quad (4)$$

The linkage could be designed so that line JL is not perpendicular to line KL; normally, however, it is designed so that angle $\alpha = \theta/2$ (line JL is perpendicular to line KL). Then Eq (4) becomes:

$$F = \frac{Rc \sin (\theta/2)}{a}$$

Combining Eq (2), (3) and (4) gives

$$F = \frac{2cT_o \cos (\theta/2) \sin (\theta/2)}{\mu a r_o}$$

or

$$F = \frac{cT_o}{\mu a r_o} \sin \theta \quad (5)$$

Based on Hertz equations, maximum stress in the contact surfaces of the shaft and disk is:

$$S = \sqrt{\frac{0.35N(1/r_1 + 1/r_2)}{b(1/E_1 + 1/E_2)}} \quad (6)$$

For materials of the same modulus of elasticity, Eq (6) reduces to:

$$S = \sqrt{\frac{0.175NE(1/r_i + 1/r_d)}{b}} \quad (7)$$

Maximum stress occurs at the contact points between idler and input shaft.

PROBLEM—TO DESIGN A FILM DRIVE

Given data are:

- Minimum output torque (2-idler system) = 4.5 in.-lb
- Coefficient of friction = 0.1
- $E = 30 \times 10^6$
- $r_o = 1.5$, $r_i = 0.125$, $r_d = 0.375$ (this gives a transmission ratio of 1.5/0.125 or 12:1)
- Thickness of disks = 0.25 in.

Symbols

a = moment arm of spring about crank arm pivot, in.
α = angle between crank arm and link, deg
b = face width of disks, in.
c = crank arm, in.
E = modulus of elasticity, psi
F = spring force, lb
μ = coefficient of friction
N = normal force, lb
R = resultant force on bearing of idler, lb
r_o = output disk radius, in.
r_i = input shaft radius, in.
r_d = idler roller radius, in.
S = contact stress, psi
T_o = output torque, lb-in.

Computations:

From Eq (2),

$$N = \frac{4.5}{2(0.1)(1.5)} = 15$$

From Eq (7),

$$S = 58{,}000 \text{ psi}$$

This stress is satisfactory. To find θ:

$$\cos \theta = \frac{r_d + r_i}{r_o + r_d} = \frac{0.375 + 0.125}{1.5 + 0.375} = 0.266$$

$$\theta = 74.5°$$

From Eq (5), keeping in mind that for one idler, $T_o = 4.5/2$, the spring should be loaded to a force of

$$F = 14.5 \text{ lb}$$

Reaction load on idler link, from Eq (3):

$$R = 24 \text{ lb}$$

This value is employed when selecting bearings for the idler link.

For REPRINT of above article, just check E92 on one of the Reader Service cards bound in this issue.

EDITOR'S NOTE: Other interesting drives recently discussed are:

"Spur-helical Planetary Gears," June 22, p 67. Here's a novel method of pairing helical with spur gears in a standard planetary system that can easily boost the reduction ratio from, say, 1:21 to 1:1600. For a reprint of this article, check E-88 on a Reader Service card.

"New Equations Locate Dwell Position of Three-gear Drives," June 8, p 80. These drives are capable of producing three different motion patterns—depending on how far the output gear is located from the input gear. The article presents equations which, for the first time, pinpoint this all-important dimension. For a reprint of this particular article, check E-85 on a Reader Service card.

IT'S EASIER THIS WAY

FINDING STRESSES in a PRESSURE-VESSEL HEAD

R E WONG, *project director*
Space Flight & Missile Dept
Bell Aircraft Corp

When author Dick Wong set out to design the propellant and oxidizer tanks for a new air-to-ground missile, the rapid weight-strength analysis method he presented in an earlier article *(PE—Oct 14, '57, p 95)* provided a good start. But to pin down all the stresses in the vessel, particularly the head stresses, proved a tougher job.

Design of the tanks (like the one above) was based on the theoretical approach of Coates, modified to account for different thickness of head and shell. Pressure tests to bursting—routine at Bell on new designs—provided a rough check. But Wong wanted to know for sure whether the stresses he had calculated from theory were the correct ones. This article shows the method he devised to let strain-gage measurements during pressure test give him the check he sought.

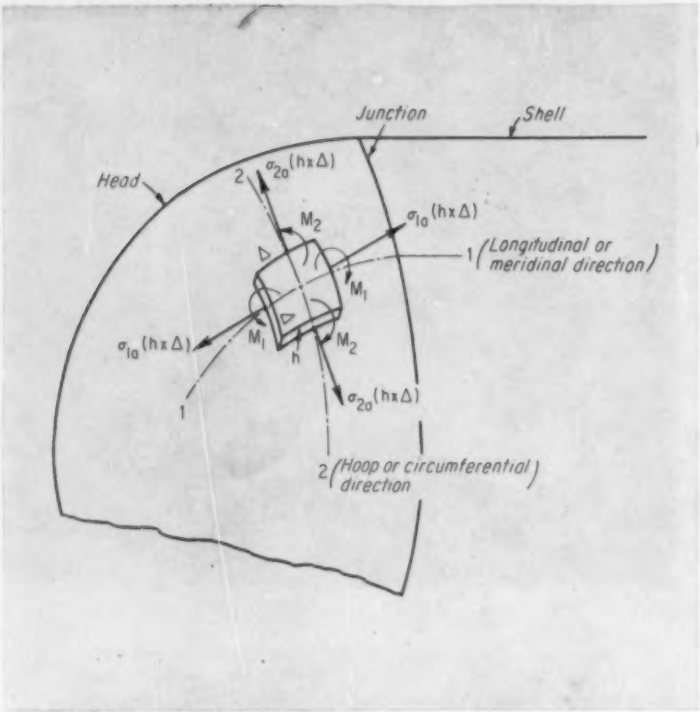
No need for strain gages inside the head where you can't see them. Here's a way to have them all on the outside— and yet determine accurately the biaxial stresses where the head and shell join. The author discusses both spherical and elliptical heads.

This stress-analysis method is an example of how new usefulness can be found for old equations. It starts off, with the simple elastic equations that relate principal stresses and strains in biaxial stress situations. But it manipulates them in such a way that you no longer have to deal with strain gages hidden away from sight.

Every designer has had a moment of frustration when faced with the "junction problem" in stress analysis of a pressure vessel—whether it be a hydraulic accumulator or a missile fuel tank. The low-cycle fatigue performance here depends on the axial or "membrane" stresses —but pure membrane theory doesn't apply in the narrow zone where the head joins the shell. Here, bending stresses do exist and must be separated out of the total, so that analysis can go ahead with the axial stresses alone and check them against endurance limits of the pressure-vessel material.

The use of strain gages back-to-back is the standard method of eliminating bending stresses from the analysis. But with pressure vessels this means a set of gages inside the head, out of view and subject to hydrostatic pressure —which requires data correction. This is where the new technique shows a way out—it allows taking strain readings on only the outside surface. Such readings can

Force Diagram Near Junction of Head and Shell



NOMENCLATURE

σ_1	Actual stress in longitudinal direction, psi
σ_2	Actual stress in hoop direction, psi
ϵ_1	Measured strain in longitudinal direction, in./in.
ϵ_2	Measured strain in hoop direction, in./in.
ϵ_{1a}, ϵ_{2a}	Strains due to axial loads (longitudinal and hoop, respectively), in./in.
ϵ_{1b}, ϵ_{2b}	Strains due to bending loads (longitudinal and hoop respectively), in./in.
σ_{1a}, σ_{2a}	Axial stresses (longitudinal and hoop, respectively), psi
σ_{1b}, σ_{2b}	Bending stresses (longitudinal and hoop respectively), psi
M_1, M_2	Bending moments (longitudinal and hoop, respectively, in.-lb
E	Young's modulus, psi
μ	Poisson's ratio
p	Internal pressure, psi
a	Radius of cylinder, in.
h	Thickness of head, in.

be made to yield component stresses if they are combined with judicious amounts of theoretical analysis.

The method requires measuring only the outer surface strains in the longitudinal and hoop directions, and calculating the axial stress in the longitudinal direction. The following step-by-step equations can give the complete state of biaxial stress in the region of the joint:

Step 1: Calculate longitudinal axial stress σ_{1a} (shown here for a sphere. For ellipsoidal head, see next page)

$$\sigma_{1a} = pa/2h$$

Step 2: Calculate hoop axial stress σ_{2a} from measured strain ϵ_2 and calculated stress σ_{1a}

$$\sigma_{2a} = E\epsilon_2 + \mu\sigma_{1a}$$

Step 3: Calculate longitudinal bending stress σ_{1b} from measured strain ϵ_1 and ϵ_2, and stress σ_{1a}

$$\sigma_{1b} = \frac{E}{1-\mu^2}(\epsilon_1 + \mu\epsilon_2) - \sigma_{1a}$$

Step 4: Calculate hoop bending stress σ_{2b} from σ_{1b} obtained in Step 3

$$\sigma_{2b} = \mu\sigma_{1b}$$

METHOD ANALYZED

In a symmetrical pressure vessel, the principal force directions are known. These are the longitudinal (or meridinal) direction, and the hoop (or circumferential) direction. Designating them as directions 1 and 2, as shown in the sketch above, the familiar elastic stress-strain equations are (see nomenclature):

$$\epsilon_1 = \frac{1}{E}(\sigma_1 - \mu\sigma_2) \quad (1)$$

$$\epsilon_2 = \frac{1}{E}(\sigma_2 - \mu\sigma_1) \quad (2)$$

Restating the same equations, but now with stress in terms of strain:

$$\sigma_1 = \frac{E}{1-\mu^2}(\epsilon_1 + \mu\epsilon_2) \quad (3)$$

$$\sigma_2 = \frac{E}{1-\mu^2}(\epsilon_2 + \mu\epsilon_1) \quad (4)$$

Near the juncture between head and cylindrical shell, the membrane stresses are usually accompanied by local bending stresses. This is because the shell wants to deflect more radially than does the head. The "moments of discontinuity" thus set up are related by Poisson's ratio, $M_2 = \mu M_1$, and so the local bending stresses are related similarly:

$$\sigma_{2b} = \mu\sigma_{1b} \quad (5)$$

Further, the recorded total strains in both longitudinal and hoop directions have two components: strain arising from axial load, and strain from bending load:

$$\epsilon_1 = \epsilon_{1a} + \epsilon_{1b} \quad (6)$$

$$\epsilon_2 = \epsilon_{2a} + \epsilon_{2b} \quad (7)$$

By working with these component strains, the bending stresses in the area can be isolated so that the axial (membrane) stresses can be found. First, the component strains are related to the stresses that cause them, in the form of equations (1) to (4):

$$\epsilon_{1a} = \frac{1}{E}(\sigma_{1a} - \mu\sigma_{2a}) \quad (8)$$

(This equation gives the longitudinal strain due to axial

loads. For the hoop strain caused by these same loads,

$$\epsilon_{2a} = \frac{1}{E}(\sigma_{2a} - \mu\sigma_{1a}) \tag{9}$$

and for bending,

$$\sigma_{1b} = \frac{E}{1-\mu^2}(\epsilon_{1b} + \mu\epsilon_{2b}) \tag{10}$$

$$\sigma_{2b} = \frac{E}{1-\mu^2}(\epsilon_{2b} + \mu\epsilon_{1b}) \tag{11}$$

To isolate the first bending-stress component so it can be computed, equation (10) is used; substituting ϵ_{1b} and ϵ_{2b} from (6) and (7):

$$\sigma_{1b} = \frac{E}{1-\mu^2}(\epsilon_1 - \epsilon_{1a} + \mu\epsilon_2 - \mu\epsilon_{2a}) \tag{12}$$

But this contains the two strain components, ϵ_{1a} and ϵ_{2a}, ultimately being sought. These can be removed for the moment by substituting their values from (6) and (7):

$$\sigma_{1b} = \frac{E}{1-\mu^2}(\epsilon_1 + \mu\epsilon_2) - \sigma_{1a} \tag{13}$$

And here, all terms are known on the right side except for σ_{1a}. How to calculate it for various head shapes is covered later.

The second bending-stress component σ_{2b} is quickly determined from (5), using Poisson's ratio. Now, the only remaining stress component to be isolated is the axial stress in the hoop direction. Equation (9) will give this, if a value for ϵ_{2a} can be found. Combining (5) and (11), and inserting ϵ_{2b} from (7) along with ϵ_{1b} from (6):

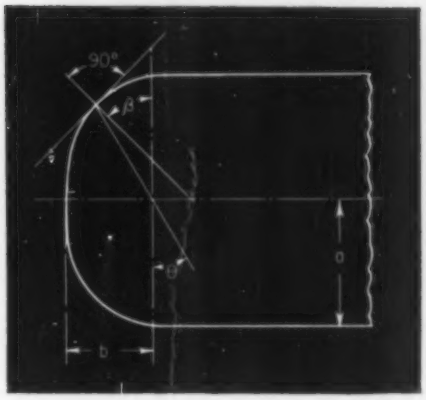
$$\mu\sigma_{1b} = \frac{E}{1-\mu^2}(\epsilon_2 - \epsilon_{2a} + \mu\epsilon_1 - \mu\epsilon_{1a}) \tag{14}$$

This has the same form as (12), so if (12) and (14) are solved simultaneously, eliminating σ_{1b}, it turns out that $\epsilon_{2a} = \epsilon_2$. That is $\epsilon_{2b} = 0$, meaning that local bending is confined to the longitudinal (meridinal) direction. Component stress σ_{2a} is quickly found now from (9):

$$\sigma_{2a} = E\epsilon_2 + \mu\sigma_{1a} \tag{15}$$

Parameters for Elliptical Head

$k = a/b$
β = arc cot $[(b/a)\cot\theta]$
θ = parametric angle



CALCULATING STRESS

Three components of stress σ_{1b}, σ_{2b}, and σ_{2a} have now been written [equations (13), (5) and (15)] in terms of known strains ϵ_1 and ϵ_2, and the unknown fourth stress component σ_{1a}. This remaining unknown must be found analytically and is readily done with reasonable accuracy by using the following equations for various head shapes:

Spherical head (see original nomenclature):

$$\sigma_{1a} = pa/2h$$

Elliptical head (see sketch above for terms):

$$\sigma_{1a} = \frac{pa}{2h} \cdot k\,[1 + (k^2 - 1)\cos^2\beta]^{-1/2}$$

The complete state of stress is now established.

EDITOR'S NOTE: For other recent articles covering stress-analysis techniques well suited to pressure vessel design, see:

"PhotoStress Analysis," Mar 2 '59, p 43—describes latest developments in a new photoelastic technique introduced in the special PRODUCT ENGINEERING report: "Photo-Stress," Sep '56, p 167.

"How Wrong Can Elastic Constants Be?" Jan 6 '58, p 68—shows why high-precision testing methods aren't always necessary for accurate design.

"Tangential Stresses in Thick-walled Cylinders," Design Digest Mid-Oct '57, p F18—shows how maximum stress can sometimes occur at the outer surface, if pressures and radii are just right.

"Rapid Weight-strength Analysis of Pressure Vessels," Oct 14 '57, p 95—offers simple weight-volume ratio formulas for cylinders, spheres and elliptical heads. Chart methods cut design time when many materials must be checked.

"How to Measure Principal Stresses," Oct 14 '57, p 101—shows how to get the most out of strain-gage analysis. Distribution diagrams for pressure vessel stresses are given, along with basic stress-strain equations.

"Three-dimensional Photoelasticity," July '57, p 135—discusses application of latest materials and techniques to pressure vessels of unusual shape.

For articles discussing special environmental problems sometimes encountered in pressure vessel design, see the following:

"Product Design for —300 F," Feb 2 '59, p 60—as more products, including pressure vessels, are required for handling supercold gases like liquid oxygen, the job of design gets harder: materials embrittle, moving parts "freeze," lubricants congeal. The article gives an understanding of this new environment.

"Stress Corrosion in Metals," Aug 4 '58, p 56—covers the characteristics of this delayed-action damage and design steps to head it off.

"How to Choose Thermal Insulation," Nov 11 '57, p 97—presents a screening chart to simplify a tough design problem. Chart compares 25 types in 3 basic groups.

"Thermal Stress Fatigue," June '57, p 175—shows how higher operating temperatures accentuate premature failure in structural parts. Materials are compared and useful design criteria cited.

"Stainless Steels for High Temperatures," Apr '57, p 135—summarizes mechanical properties, structural stability and fabrication problems for 5 austenitic and 3 martensitic alloys. Master chart gives comparison at a glance.

"Metals at Elevated Temperatures," Oct '56, p 160—hot and cold behavior of metals compared, using homologous temperature scale. Fatigue and rupture stress are discussed as alternate design criteria.

FOUR WAYS to STOP a MOTOR

They range from mechanical to capacitor braking for an induction motor—and the choice requires weighing several factors. The author rounds up the comparison in a handy table.

CHESTER H BUCHANAN, *applications engineer*
Small Ac Motor Dept, General Electric, Schenectady

When an induction motor must be stopped in a hurry, one of these four basic methods—mechanical braking, plugging, dc dynamic braking, and capacitor braking—will meet most requirements. Each method has its own advantages and limitations depending on the braking torque, power dissipation, circuitry and equipment needed. Sometimes the need for fail-safe operation is also a factor.

Mechanical Brake. This is the most common type, using shoes clamping a drum, or a friction disk with axial clamping. Most of these brakes are set by springs and released by a solenoid, and are therefore fail-safe; braking torque is preset, and adjustable by changing the spring tension. Variable braking torque requires a control panel; this construction does not fail safe.

In general, the shoe brakes have more heat capacity than disk brakes and therefore can be used on more severe duty cycles. All of them will handle any stopping duty cycle the motor can handle in starting.

Mechanically, methods of actuating these brakes vary considerably—some are opened by direct magnetic action, others through yokes or linkages.

Mechanical braking usually works out best where: braking torque is 100 to 150% of motor full-load torque; where holding is wanted, in addition to stopping; where frequency is low enough to avoid repeated adjustment and maintenance. Equipment is simple and easily understood when a mechanical method is used, and heat is dissipated outside the motor.

Plugging. This method of braking merely reverses the line connections to the running motor so it will try to go backwards; then, the power is cut off as it comes to rest. Braking torque depends on the motor design, and it cannot be adjusted except for wound rotor motors, or by insertion of resistance or reactance in series with motor terminals. An important limitation is that the motor-heating during stopping is three times the heating of one acceleration. For duty cycles involving repeated reversals, heating may be so great that some other method of stopping is necessary.

Where the application requires reversal of the drive, plugging can be obtained with little added expense. There is no wear, and a plugging switch takes less space than a brake.

Dc Dynamic Braking. When stationary magnetic field is set up by applying dc to the motor stator, the motor then responds much the same as an alternator feeding a low-impedance load. Braking torque is a function of the dc power supplied, and can be varied readily by series resistance in the dc supply.

Braking is done electrically and losses must be dissipated in the motor. As compared with plugging, the heating is much less, but for induction motors, braking torque is low at high speed and peaks at around 3 to 5% speed, depending on the type of motor. But for a wound-rotor motor with 100% resistance in the secondary circuit, the braking torque is nearly proportional to speed, with zero torque at zero speed and maximum torque a little higher than 100% speed.

Dc dynamic braking requires special control components subject to maintenance. The motor may be damaged if control fails to disconnect dc power when motor stops. But it can provide emergency braking without the possibility of motor reversal, and it takes no extra space at the motor as does a plugging switch or a mechanical brake.

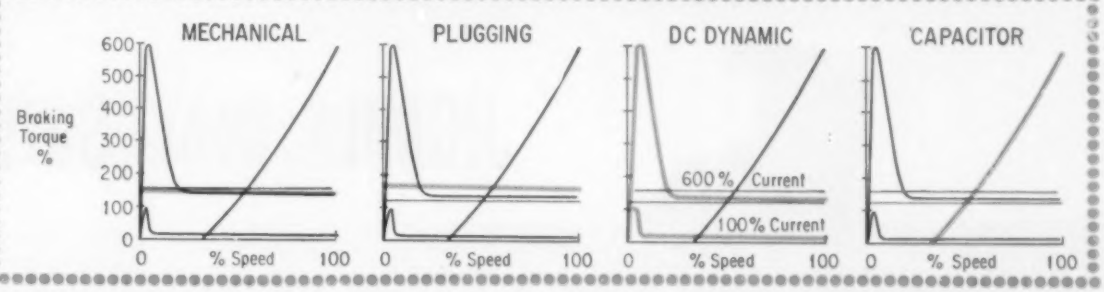
Capacitor Braking. Balanced, 3-phase capacitors can be connected across motor terminals and switched with the motor. When the motor supply is opened, the capacitors supply a low-frequency current that produces a field rotating much slower than the synchronous speed. As long as rotor speed is greater than the rotating magnetic field supplied by the capacitors, the motor operates as an induction generator, dissipating power in the motor and any external resistance in the oscillating circuit.

For most applications, capacitance is selected for resonance at 15 cycles. Braking torque will start at maximum value on opening the supply, and drop off as speed decreases, becoming zero at approximately 25% speed. Below this speed the load will coast to a stop, with coasting time dependent on friction and inertia of the load.

Addition of resistance or inductance in the oscillating circuit may be desirable to control the peak braking torque at high speed. But this method does have an important advantage where overtravel must be kept low.

Capacitor braking introduces the lowest internal heat-

HOW THE 4 METHODS COMPARE



Equipment Required	Standard single-speed starter Brake	Reversing starter Plugging switch	Standard single-speed starter with extra interlock Brake panel including rectifier, contactor and timing relay	Standard single-speed starter Capacitors
HP Range at 1800 rpm	Up to 2500	Up to 3000 plus	Up to 25	Up to 10
Heating in equivalent accelerations	0	3	1	½
Advantages	Braking done mechanically Energy dissipated in brake, not in motor Torque adjustable at application Simple, easily understood	Braking done electrically No wear or adjusting Plugging switch takes less space than brake	Braking done electrically No wear or adjusting Torque is adjustable at application No extra space requirements at motor No possibility of motor reversal Less motor heating than for plugging	Braking done electrically No wear or adjusting No extra space requirements at motor No possibility of motor reversal Lowest motor-heating of all electrical braking methods No danger of applying power to standstill motor No extra control required Less overtravel, generally, than for other methods
Disadvantages	Periodic adjustment Parts replacement Possible space problem	Possible motor reversal if control fails No torque adjustment Severe motor heating	Needs special control panel Low braking torque at high speed Limited in power range	Torque adjustment limited once application has been made Motor contactor must be derated for capacitive load Capacitors must be carefully selected
Precautions	Check periodically for wear	Check heating on duty cyde	Motor may be damaged if control fails to disconnect dc power when motor stops	Line current is 2.5 to 3 times motor full-load current Overvoltage may need to be controlled

ing of the electrical braking methods. Also, there is no danger of motor reversal. No extra control is required and when they are running, the capacitors produce power factor correction for horsepower equal to two or three times the motor rating. However, line current is 2½ to 3 times the motor full-load current and only the motor current must flow through overload heaters in the motor starter.

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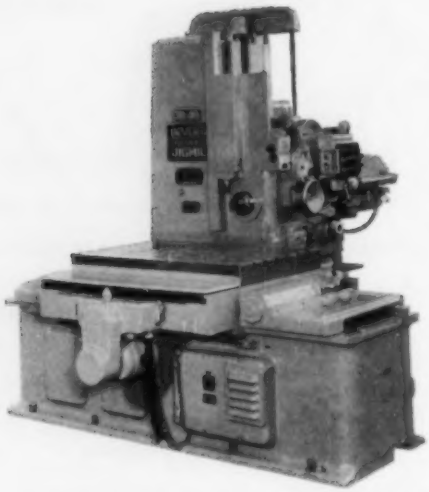
EDITOR'S NOTE: The following earlier articles include design data and recommendations for various motor-braking methods:

"Torque Motors and Brakes," Apr '57, p 146, speed-torque characteristics and control arrangements for drives requiring limited, stalled, or backward rotation for braking and tension control; "Power Absorption Devices," Mid-Oct '57, p E-13, mechanical braking systems including eddy current, hydraulic and compression retarding; "Electrical Braking for Machine-tool Applications," Mid-Oct '55, p H-14, plugging, regenerative braking and dc braking evaluated, with emphasis on dc braking. Also, "Dc Brakes for Ac Motors," Sep '52, p 156, operating characteristics, control circuits and applications.

JIGMILL DIAL Sets



Vertical and horizontal distances picked from blueprints are dial-set, without computation, to position the worktable and spindle head. While machine is working, operator can set up next dimensions to be called in at push of button.

Simple mechanical system uses no electronics measures to an accuracy of plus or minus 0.001 in. with a repeatability in positioning of 0.0001 in. Unit will position in plus or minus directions from any given datum point even if the point lies outside limits of the jigmill. Numbers entered into control system are limited by the counters themselves, plus or minus 1000 in., and not by the physical length or height of the machine. Diatrol measuring system is applied to Spiramatic Jigmils by DeVlieg Machine Co, Royal Oak, Mich.

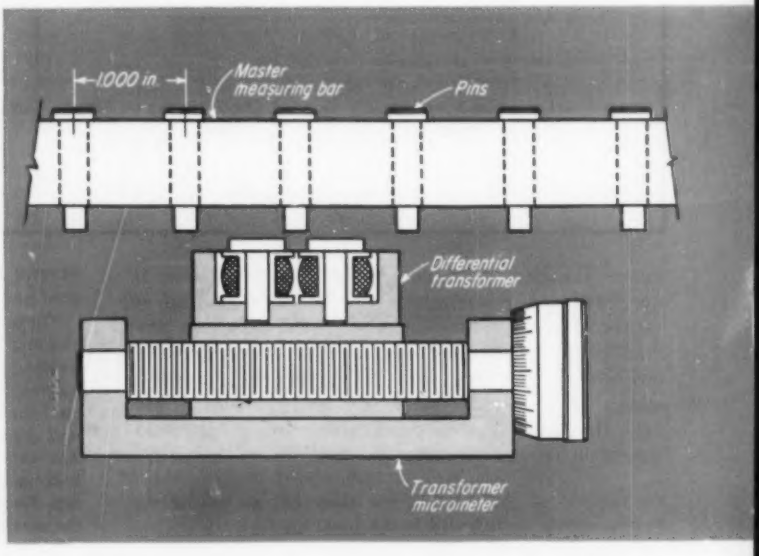
Zeroing . . . ▸ is a matter of aligning the tool and work at a selected datum point or some known distance from datum, and placing the value on the dials. This is done with the micrometer-selector knob and the outer pin-selector knob (setscrew loosened). In final step, both the zero adjustment and inner-pin-selector knob are turned until the cam indicator switch light flashes on and the null meter reads zero.

Setting a dimension on the dials rotates the sensing-head turnoff cam by means of a differential. The angle of cam displacement is proportional to distance that the new position is away from the existing location. Movement towards the new location winds down the differential, as the rack rotates the three gears in the sensing-head assembly.

When the sensing head is within $\frac{1}{8}$ in. of the correct pin, the cam has been rotated back to its "zero" position and the sensing head is energized. The sensing head, a differential transformer, sends a plus or minus signal to the positioning system until the pin is centered exactly over the head and the signal is nulled out. When this positioning is complete, machining commences and the next locator dimension may be set into the control.

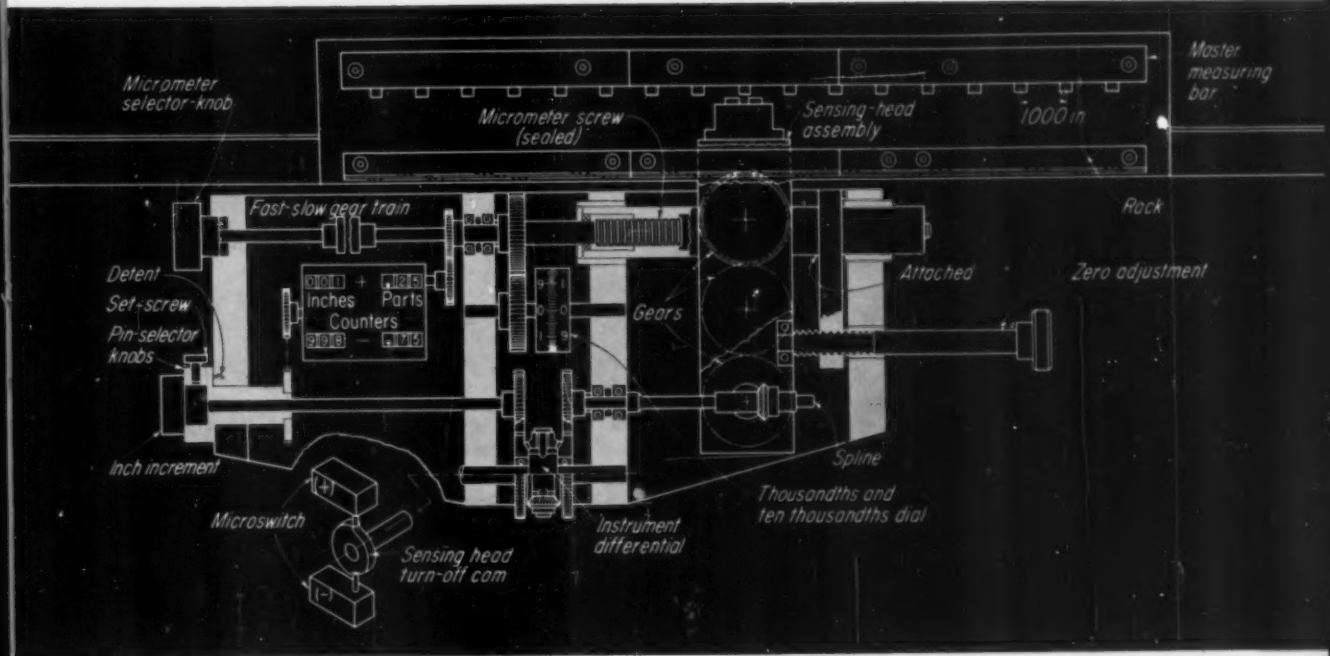
Basic measuring elements . . . are the master bars mounted full length of horizontal and vertical slides. Hardened pins, 0.200 in. dia, are spaced 1 in. apart along the bars. Nubs of the pins are eccentric to allow 0.0025-in. adjustment. During calibration the pins are rotated to provide precise adjustment between pins, and then locked with a setscrew. There is no physical contact between the pins and sensing head; this eliminates wear or damage.

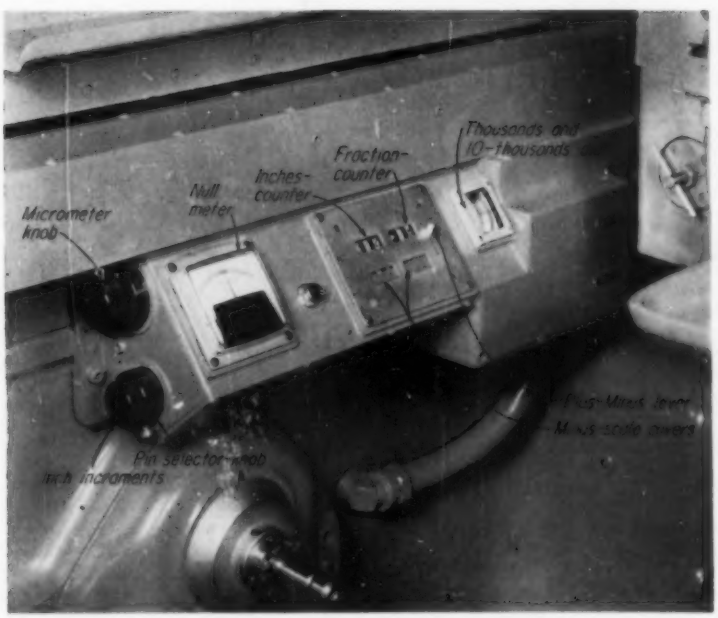
Since the pins are set at 1-in. intervals, a micrometer is used to offset the sensing head for fractional distances.



IN NEW PRODUCTS

the Dimensions



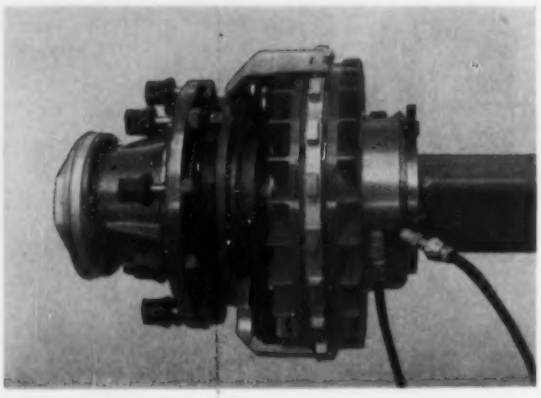


Counter-and-dial combination . . . indicates micrometer settings; this is to eliminate operator error in reading and to simplify gear design. Shutters hide the minus dials when plus numbers are set in, and vice versa. The inches-cover is automatic but the parts-cover must be flipped by hand. The operator may mix numbers—plus integers and minus decimals for example—to speed dial settings. The machine moves in the direction dictated as shown by the dials, even with mixed numbers, and cannot get lost or travel in the wrong way.

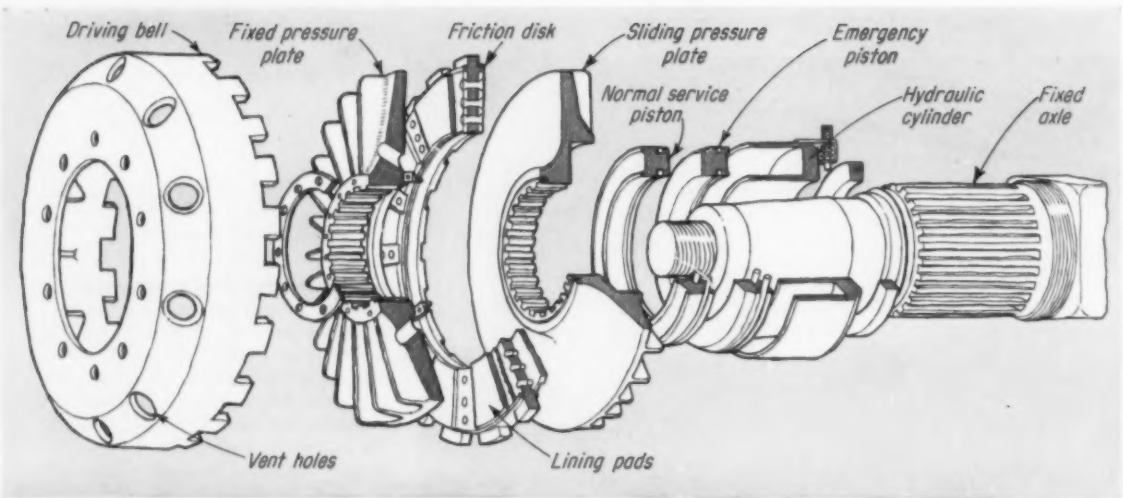
TRAILER BRAKE COOLS SELF CENTIFRUGALLY

Efficiency of this French brake is increased by lining both sides of the disk brake and using total-contact pressure plates. Spaces in the lining pattern act as centrifugal fan to pull air through unit for better cooling.

Designed for axles of 10-13 metric tons used on semi-trailers, the brake fits inside a 20-in. tire rim and has better heat dissipation than the enclosed-drum type. Produced by Titan, Paris, France.



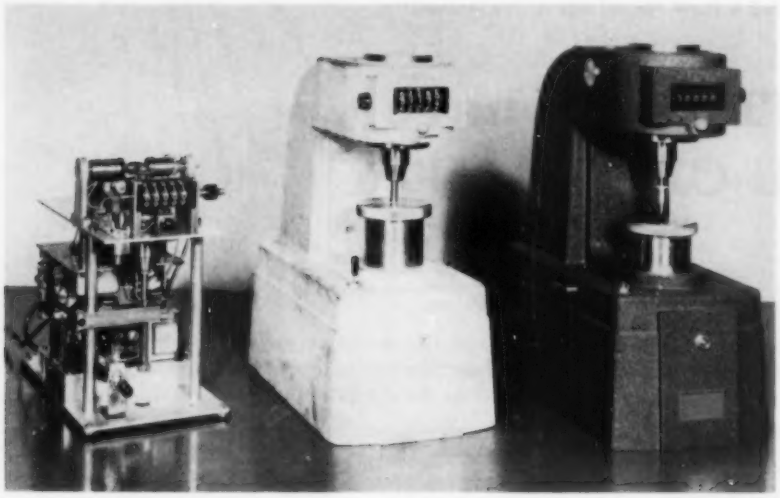
Braking action . . . results when brake disk is clamped between the fixed and sliding pressure plates. The sliding pressure plate is forced against the brake disk by means of an annular hydraulic piston. French law requires that air-hydraulic brakes in this weight category have an emergency actuating system. In system shown, emergency mechanism consists of a second annular piston with a separate hydraulic circuit in same cylinders. Compensation for lining wear is accomplished by rotating the threaded retaining ring behind the hydraulic cylinder.



A disk brake . . . usually has a plain steel disk with friction material on fixed caliper which clamps on disk to provide braking action. By contrast, this unit has lining material on both faces of disk. This spreads out the heat because the linings cover entire surface of rotating friction disk, increasing braking area.

Positive air flow is generated by gaps between the rotating lining segments. The action is that of centrifugal impeller. Air is pulled through ventilation holes in the driving bell, between the fins on the fixed pressure plates, through the vent holes and out by means of the gaps in the brake lining. Fins on the nonrotating disks also help to dissipate heat.

TO ONE MORE DECIMAL POINT

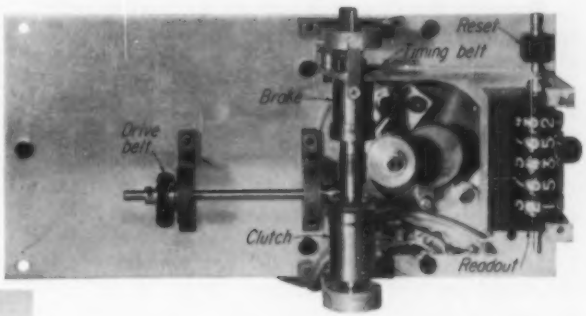


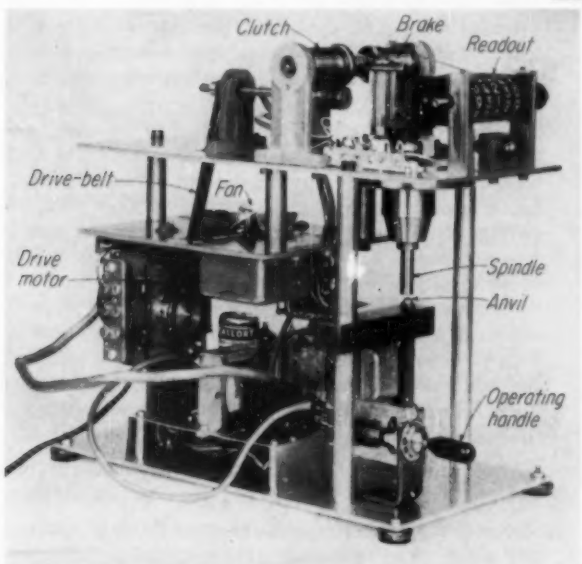
Micrometer measures without pressure to 0.00001 in. (10 millionths). Digital readout and electronic micrometer stop assure accuracy independent of operator skill.

Earlier model had a four-digit readout with right-hand numeral reading tenths of a thousand. Development of new model presented two problems—structural stability of micrometer casting, and reduction of overshoot of powered micrometer screw. Complete redesign increased casting stiffness to required level, and the improved micrometer drive with a Simplatrol brake stops spindle in 7 millisec. Model PDR Electronic Micrometer is produced by J W Dice Co, Englewood, NJ.

Steps in development . . . include breadboard model, wooden mockup and final production model. Complex one-piece casting used in final model was designed with column depth greater than throat depth for desired structural stability. Throat section is beefed up at critical points for increased stiffness and casting is annealed before machining to prevent drift in service.

Part to be measured is placed on the anvil, and the lever switch pulled toward the operator to lower the spindle. A motor drives the micrometer screw, lowering the spindle until it touches the work; upon contact, relay-actuated brake locks the counter and a green light signals that a reading may be taken. When the lever switch is released, the micrometer spindle retracts automatically.





Breadboard model . . . (top and side views) checked out components and performance of system, aiding in selection and specification of components for production model. Fan is included to cool components and provide temperature stabilization throughout casting.

Repeatability problem was solved by reducing number of rotating parts to be stopped and then reducing the inertia of each part. By inserting an electric clutch in the drive train after the first worm reduction, inertia of motor and driveshaft was eliminated in stopping. Further reductions in inertia came from replacing a gear drive to the counter with a miniature timing belt and by using plastic instead of die-cast counter wheels.

When the micrometer spindle contacts the work, a relay disconnects the clutch and energizes the fast-acting brake to stop and lock the counter. Both clutch and brake are powered by a 24-volt dc power supply in base of the casting.

You've built a prototype and it works. But problems still face you. For example, to what extent does the new model outperform previous ones? Also, what variations in performance can you expect for units that will pass production tolerances? Here's how to set up . . .

EXPERIMENTS that have STATISTICAL CERTAINTY

WILLIAM J HILL, *manager, Statistical Services Section*
Ford Instrument Div, Sperry Rand Corp

The big hazard in guesswork is the wrong decision. A statistically designed experiment cannot completely remove that hazard—nothing can—but it does let the test engineer know magnitude of the risks and the steps that can be taken to minimize them. One such statistical design is the Latin Square, which is efficient for experiments where it can be assumed that each variable has an independent effect on the result. But when variables interact—which is more often the case—a more thorough approach is called for. It involves three key steps.

1. **Recognize that there is an element of chance in every test result.** This is the first, and perhaps most important, of the three steps. A flat statement that "Black Box X delivers 25.3 hp with certain fixed input conditions" is impossible to support with any kind of test results–no matter how thorough; there is always some source of variation which cannot be precisely measured.

There are four main sources of variability in experiments which, if not recognized, can cause errors in the readings: the operators who conduct the test and collect the data, the test equipment, the test conditions, and the tested device itself. Variations caused by the first two can be minimized by repeating some tests–using different operators and, if possible, different test equipment. Variations resulting from test conditions can be reduced by randomizing the sequence of the tests. The final trouble source can be minimized by carefully choosing the sample to be tested–it should be a good representative of its class and give readings that are repeatable. Otherwise it will be necessary to enlarge the experiment.

2. **Measure the effect on the output when an input, or several inputs are changed.** However, it is not only what is measured, but how the measuring is done that counts.

For example, one way of collecting data–the classical way–holds one variable as a constant while the other variable is changed. When a point of maximum output is found, the other variable is then held constant and the first one changed to determine if maximum output can be improved. Result of these tests yields a maximum for all conditions of both variables–or so it seems. Drawbacks of this method are many; here are a few.

- It is often impossible to hold one variable "constant" over a sufficient period of time.
- In many cases, two variables acting together have more effect on output than the effect of single variables acting independently on the output.
- The experiment is usually run in a non-random manner, thereby permitting changes in test conditions to mask the true maximum output.

3. **Compare the output for one value of a variable with output for another value.** Is the change significant? The only meaningful method of comparison is through a statistical analysis. It is insufficient, for example, to state, "When variable A is changed from level 1 to level 2, output increases 1%." Is the 1% due to A, or to errors that crept into the experiment?

Statistics enables the experimenter to attach a confidence value to his results. He can then state, "When variable A is changed from level 1 to level 2, 95% of the time the output will increase by 0.9 to 1.1%."

DESIGN OF THE EXPERIMENT

In the manufacture of precision gyros for missile equipment, the following problem was encountered. A vendor supplied bearings for the gyro to a tolerance of −0.0000 and +0.0002 in. He was instructed to measure each bearing before shipment and divide them into four classes labeled A, B, C, D, each with 50 millionths' spread. Using these code letters, the purchaser matched shaft and bearing at assembly. Many times, however, parts that should go together (on paper) did not. When the shaft was reinspected, the same measurements were obtained (within 10 millionths). When bearings were remeasured, however, some of those labeled A wound up as B and some labeled B were regraded to C.

To pin down the cause of this difference, we will design an experiment for the purchaser which will enable him to determine whether the difference is a result of different measuring machines, different calibration rings (used with measuring machines), or different operators. This experiment has two phases:

1. Determine ability of the experiment to accept the hypothesis when it is true, and reject it when false.

2. Select the type of experiment—one that can measure the effects to be evaluated.

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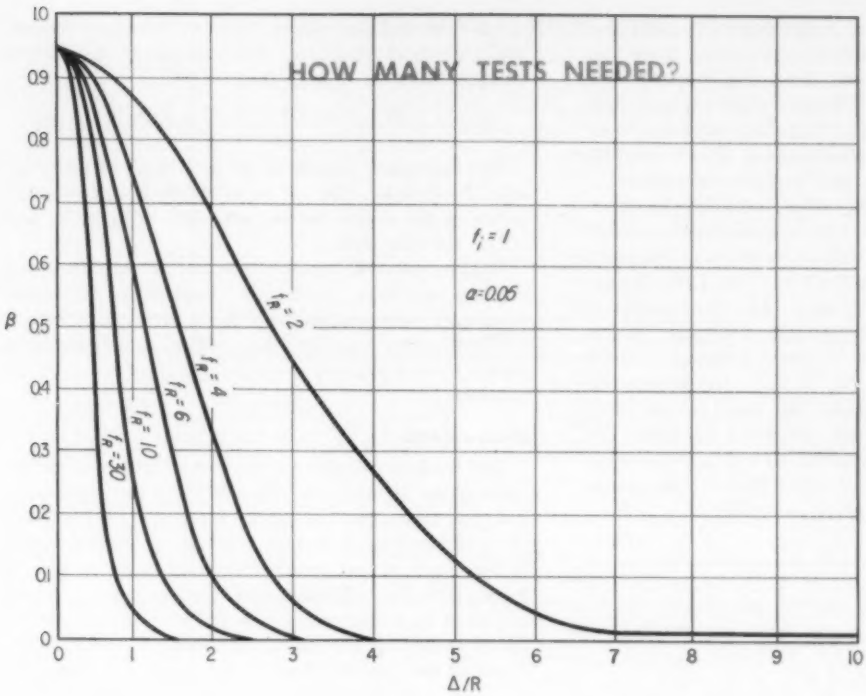


The hypothesis

To determine (1), begin first with an hypothesis—a statement which the statistical results will attempt to prove or disprove. If it is false, the statistical results should also show what variables are responsible for its rejection.

There are two basic types of hypotheses. A Null Hypothesis, for example, states, "There is no significant difference between the measurements by the vendor and those by the purchaser." The Fixed Difference Hypothesis, on the other hand, states, "There is a fixed difference of x millionths between measurements by vendor and those by purchaser."

For this problem, the null hypothesis is chosen. Because it can never be proven (or disproven) with absolute accuracy, there are always two possibilities for a correct decision and two possibilities for an incorrect one. These are summarized as follows:

True Situation	Decision on Hypothesis	
	Accept it	Reject it
Measurements the same	correct	incorrect
Measurements different	incorrect	correct

On the one hand, then, there is the risk of judging a difference in measurement as significant when it is only experimental error that causes the difference. The risk of this wrong decision (rejecting a null hypothesis when it is true) is denoted by α. It is also possible that different measuring techniques cause a real difference in the measurements, but the experimental error conceals the difference. This risk is denoted by β.

Select parameters

Both these risks are weighed before beginning the experiment. It is common statistical practice, in experiments of this kind, to choose 0.05 as the probability for both types of error.

Three other decisions must be made before setting up the experiment. First, how many levels (denoted by $f_1 - 1$) of each variable must be tested? In the case of the gyro-bearing problem, there are four variables (machines, calibrating rings, operators, bearings); and levels of each are already fixed by the nature of the test—two levels for machines, calibrating rings and operators (one from vendor, one from purchaser) and four levels for bearings (A, B, C, D).

Second, what average change in output, Δ, justifies rejection of the hypothesis? For this example, it is estimated that a difference of 10 millionths of an inch between purchaser's readings and vendor's readings is sufficient to reject the null hypothesis.

Third, what is magnitude of the experimental error—how repeatable are the measurements? Repeatability R can sometimes be determined from data collected during calibration of the test fixtures. Other times, it is simply an estimate. In this case, R is estimated to be 10 millionths. This estimate is only for purposes of setting up the experiment. It will be computed with more accuracy in analysis.

Knowing the number of variables and the number of levels for each, design of the experiment depends only on whether the individual tests in the experiment will be rerun—and if so, how many times. The total number of retests in the experiment, f_R, can be found from the curves at the top of the page. With the values of f_1, α, β, Δ, and R estimated above, the curves show that f_R is 30—thirty tests must be repeated to provide a decision ability consistent with the risks.

The type of experiment

In all experiments, the most important reason for making the test is to discover main effects—those variables

acting independently. Some experiments also call for an evaluation of interaction effects—discovering those variables which, in combination, effect the output. Most factorial-type experiments will successfully evaluate both main and interaction effects. There are two basic types: full-factorials include all combinations of all variables; fractional-factorials include only certain combinations.

The full-factorial allows investigation of all main effects and all interaction effects. Fractional-factorials evaluate all main effects and some interaction effects—except for that special class of fractional-factorial, the Latin Square, which evaluates main effects only. The disadvantage of a full-factorial is the number of tests that must be run; if there are a large number of variables and many levels of each, a tremendous number of tests may be required.

Because of the few variables and levels in this problem, a full-factorial is chosen, requiring 32 tests. But because 30 tests must be repeated, all tests are run twice, giving 64 individual pieces of data. Here are the results (measurements in millionths of an inch).

Machine		Purchaser				Vendor			
Ring		Purchaser		Vendor		Purchaser		Vendor	
Operator		P	V	P	V	P	V	P	V
BEARING	A	5 0	0 10	10 0	10 5	30 15	20 40	20 35	30 20
	B	50 40	50 60	60 60	60 65	70 50	60 80	60 75	60 45
	C	100 95	95 100	100 110	100 90	115 95	110 95	95 115	125 100
	D	150 140	145 145	155 160	155 150	165 180	155 165	165 150	165 180

ANALYSIS IN 3 STEPS

The analysis of this data involves three steps: (1) determine repeatability, R, (2) analyze main effects, (3) analyze interaction effects.

Repeatability

Shown below are the repeatability figures. They are simply the average spread between readings obtained under identical conditions. For example, repeatability of readings taken on bearing A is

$$R = \frac{5 + 10 + 10 + 5 + 15 + 20 + 15 + 10}{8} = 11.2$$

This average is calculated for each level of each variable. In addition, over-all repeatability is calculated by averaging the spread between the two readings in each cell of the data table.

Variable	Level	R
Machine	Purchaser	6.6
	Vendor	16.6
Ring	Purchaser	11.9
	Vendor	11.3
Operator	Purchaser	11.9
	Vendor	11.3
Bearing	A	11.2
	B	11.9
	C	13.8
	D	9.4
Over-all Repeatability		11.6

Repeatability of vendor's machine is evidently very much poorer than purchaser's. Apparently, the vendor must improve repeatability if he is to supply properly graded bearings (provided there are no other differences between his measuring methods and those used by the purchaser).

Main effects

But there is still the question of whether his average readings are significantly different from the purchaser's. Two-way tables give the quickest answer. They are simply a comparison of average readings for a combination of two levels of two variables. For example, in the following table the combination of P machine and P setting ring gives an average reading X of 74.1 millionths (computed by adding all readings involving P machine and P setting ring and dividing by the number of readings).

Variable		Machine		Ave. (X)
	Level	P	V	
Ring	P	74.1	90.3	82.2
	V	79.4	90.0	84.7
Ave. (X)		76.7	90.2	83.4

Similar tables are made for each of the other combinations of variables. The averages between levels of any one variable are different—76.7 compared to 90.2 for machines, for example. But are they significantly different or simply a result of experimental error (lack of repeatability)? In statistical analysis, a significant difference is one that falls outside control limits established on the high and low sides of the distribution curve. If the average of all distributed values is X', the upper and lower control limits are

$$X' \pm \frac{(t)(R)}{1.128\sqrt{d}}$$

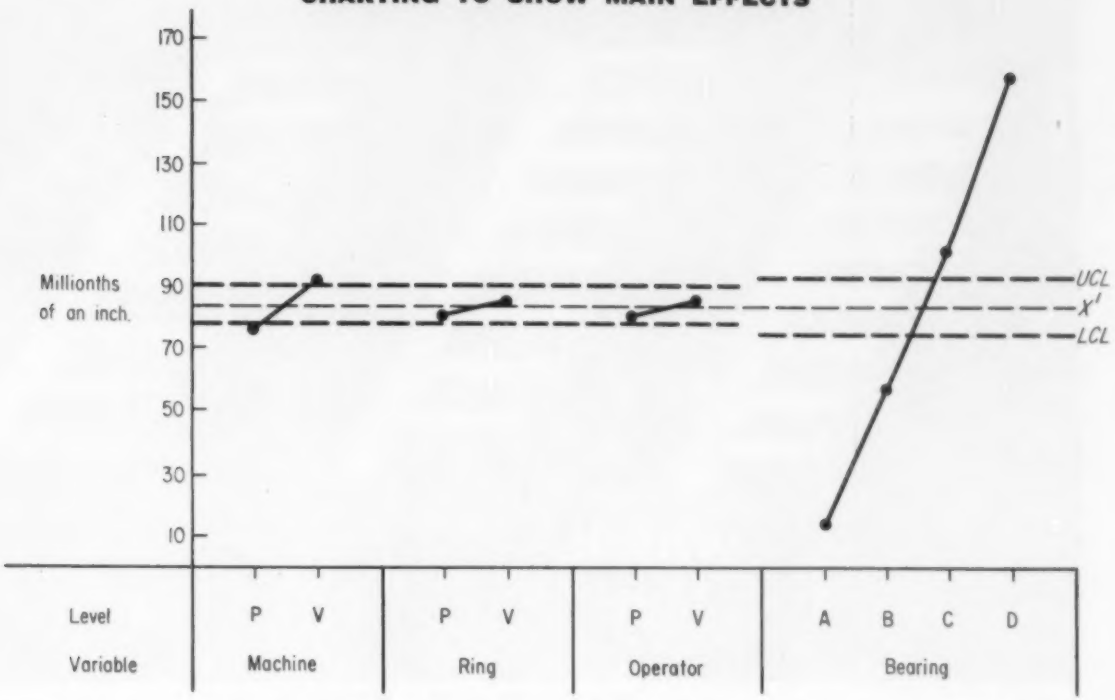
where d is degrees of freedom (one less than the number of measurements involved), R is over-all repeatability, and t is a probability factor that depends on α and d (tables of t are available in most statistical texts). The constant, 1.128, limits the equation to distributions in which repeatability is based on samples of two. In this problem, there are two sets of limits: one for variables with two levels (machines, setting rings, and operators); and one for bearings, which has four levels. Limits on variables for two levels, for example, are

$$83.4 \pm \frac{(2.04)(11.6)}{1.128\sqrt{31}} = 87.11 \text{ and } 79.69$$

where 2.04 is read from t table at 31 degrees of freedom and $\alpha = 0.05$.

Control limits and values from the two-way tables are plotted on a chart (shown at top of next page).

CHARTING TO SHOW MAIN EFFECTS



The chart shows that changing the measuring machines and bearings has a significant effect on readings. (It was known, of course, that bearings would have a significant effect—otherwise there would be no point to grading. Analysis of this effect was included only as a check.)

Interaction effects

The two-way tables, which were drawn up for main-effect analysis, gave a comparison between the grand average of all readings and the average when one level of each of two variables was involved. This reading deviated from the grand average primarily (it is assumed) because of main effects . . . and also, perhaps, because of interaction effects—two variables working together to give a change in output that would not occur with either variable alone.

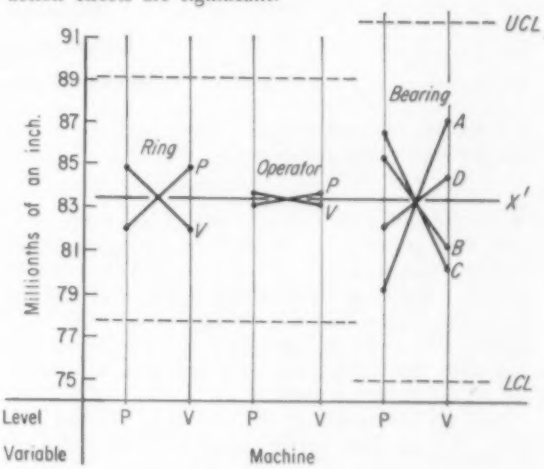
To compute the extent of this latter effect, simply subtract individual effects of each variable from the two-way average. Referring to the two-way table for main effects, the interaction between *P* machine and *P* setting ring is computed by subtracting effect of *P* machine (76.7 − 83.4 = −6.7) and effect of *P* ring (82.2 − 83.4 = −1.2) from two-way average between *P* machine and *P* ring (74.1). This gives a value for deviation because of interaction between the levels of these two variables:

$$74.1 - (-6.7) - (-1.2) = 82.0$$

Compute this interaction effect for all possible combinations of all variables and plot on control chart with control limits computed as before. Control limits for the ring and machine, for example, are set at

$$83.4 \pm \frac{(2.151)(11.6)}{1.128\sqrt{15}} = 89.1 \quad \text{and} \quad 77.7.$$

All interactions between machine and other variables are shown below. The other interactions can be plotted the same way. But it will be found that none of the interaction effects are significant.



Analysis of the data shows that the vendor's repeatability is poorer than the purchaser's. He must therefore concentrate on improving this either by using the same measuring equipment, or by taking several readings on a bearing and averaging them.

In addition, because the vendor will continue to use his machine and setting ring while the purchaser continues to use his own, the purchaser can compensate for the difference in measurement by adding 13.5 (that is, 90.2 − 76.7) millionths to the vendor's measurement. This way the vendor's measurement will correlate with the purchaser's and assembly will be simplified.

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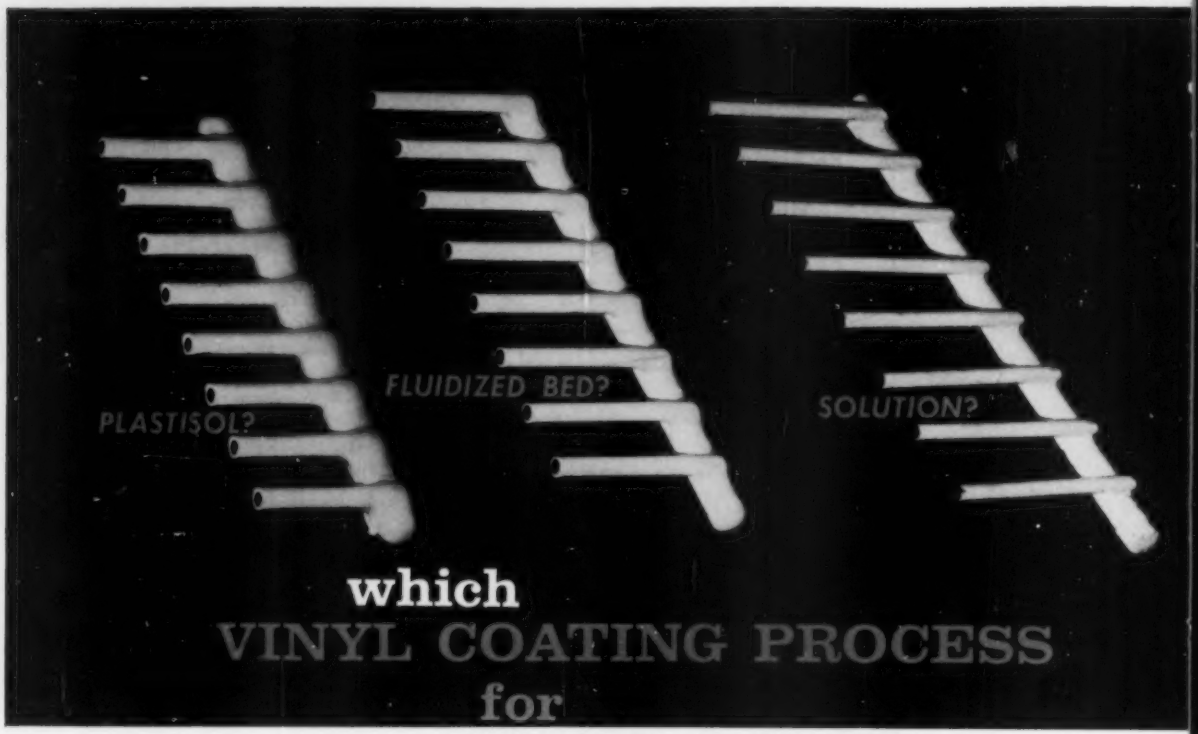

which VINYL COATING PROCESS for METAL PARTS?

These are the three basic methods for coating preformed parts. A fourth process—laminated film—is included to extend the comparison to post-formed parts as well.

F J NAGEL, *vice-president*
Polymer Processes Inc, Reading, Penna

The colorful vinyl coatings you see on many metal parts have proven to be resilient, formable, resistant to wear and chemicals, and easily embossed with decorative patterns. Based on vinyl chloride resins, they are relatively inexpensive and can be applied by many techniques. But which coating process for the performance you want? This choice can be as important as selecting the vinyl formulation itself.

Here's a comparison of the four most common processes. It rates them on six major factors of design.

1. Thickness Range

The minimum coating thickness possible with the **Fluidized-bed Method** depends on gage or mass of the substrate, melt-flow characteristics of the vinyl coating powder, and the choice of processing cycle. Below the 5-mil minimum thickness shown in the accompanying table, pinholes will usually occur in the coatings. The upper limit of about 60 mils can be substantially exceeded through the multiple preheat-dip technique (the hot, coated part is reimmersed in the fluidized bed and, after withdrawal, postheated). Maximum thickness on one coat depends on mass of the part, or its heat-holding power. For example, a heavier single coat can be applied to a 10-gage than to an 18-gage panel. Flow properties of the powder, also a critical factor, can be widely varied.

With the **Plastisol Technique** it is edge coverage, rather than pinholes in the coating, that determines minimum coating thickness. A plastisol, being a liquid, has the normal tendency to pull away from sharp edges and projections, and edge coverage suffers as the coating is made thinner. Otherwise, quite thin coatings are producible, especially when organic solvents are introduced to lower the viscosity—here the coating material becomes known as an organosol.

Maximum and minimum film thickness for **Film Method** (vinyl-metal laminate) are mainly a matter of practicality. It's possible to use extremely thin vinyl films (under 1 mil) but this is normally unjustified because of film cost, plus the application problems. Solution coatings will give the very thin coatings at much lower cost. Similarly, very heavy vinyl films normally are not used. Film 100 mils and over can be very expensive compared to equivalent coating thicknesses obtainable by fluidized-bed and plastisol techniques.

With the **Solution Method** very thin films are practical—by lowering the solids content of the coating material. Also, maximum thickness per coat depends on solids content. While theoretically there is no maximum

VINYL COATING METHODS COMPARED AT A GLANCE
(for a single coat)

Characteristic	Vinyl Application Method			
	Fluidized bed	Plastisol	Film	Solution
Thickness range, mils	5–60	10–100	5–30	0.1–12
Thickness uniformity	good	poor to good	excellent	poor
Edge coverage	good	poor	nonexistent	poor
Appearance	excellent	fair	excellent	excellent
Substrate limitations	some	none	none	none
Coatable substrate shapes	a few limitations	limited	very limited	no limitations

the four coating methods

. . . **Fluidized Bed** This is the newest of the coating techniques. Here the viny material, in powder form, is "fluidized" by an upward flow of air through the bottom of a specially constructed, open-top tank containing the powder. When air-fluidized, the powder looks like a true liquid. The part to be coated is preheated to a temperature at or above the flow point of the vinyl powder, then is dipped into the bubbling bed for a few seconds. The powder particles sinter onto the heated surfaces and coalesce into a smooth, continuous film. A short postheat or afterbake is often desirable.

. . . **Plastisol** Here the part is dipped into a liquid vinyl plastisol, then withdrawn slowly and at a controlled rate to minimize drip and sag marks. The coated part is now placed in an oven at 350-400 F to fuse the plastisol, which is a mixture of discrete particles of vinyl resin in a liquid plasticizer, into a tough and flexible coating.

. . . **Film** Calendered vinyl film is adhered to a flat metal sheet by special adhesives, heat and pressure. A thin layer of adhesive is applied to the metal panel or coil stock as it unrolls, and the film smoothed on immediately. After the bond is fully cured, the laminate may then be fabricated by ordinary sheet forming technique, using polished dies.

. . . **Solutions** Vinyl resin formulations in organic solution are applied by several common techniques—spray, dip, flow coat and roller coating. Baking at 250 F or higher is usually required for best performance. Multiple coats, with at least a partial bake in between, are common practice although recently developed dispersions, using a phenolic primer, can be sprayed on—to thicknesses up to 12 mils.

limit on thickness of coatings deposited from solutions or dispersions, the practical limitation is quite low compared with fluidized-bed or plastisol coating because multiple coats run costs up. Maximum thickness is rising steadily, however, as new formulations are developed.

2. Thickness Uniformity

For a vinyl coating applied by fluidized-bed process, uniformity is quite good–particularly because of the heavy thicknesses applied. On flat surfaces, it is approximately equal for all four techniques. On irregular shapes, coating-thickness uniformity can be rated in decreasing order: solution, fluidized bed, and plastisol (film technique is applicable only to shapes that can be fabricated from the vinyl-metal laminate).

Variations in thickness heavily influence appearance of a part. Low thickness given by solution coatings makes even a sizeable variation difficult to detect. Fluidized-bed coatings look uniform because their thickness varies only slightly. Plastisol coatings can appear quite uneven, although carefully controlled application conditions will help. For best uniformity, much more precision in application is needed with plastisols than with the other three.

3. Edge Coverage

Over sharp edges and projections, fluidized coatings cover most efficiently. This is because the higher viscosity of a powdered coating, as it melts and coalesces, allows a much more substantial retention of the coating than does the lower viscosity of liquid coatings–which causes "pull-back" from sharp edges. Good coverage of edges can greatly increase resistance of the part to weathering, chemical, and peeling. The vinyl film-metal laminate has zero edge coverage.

4. Appearance

Solution coatings are the type that give the conventional painted appearance. Plastisols often result in sags, drip marks or other irregularities unless withdrawal rate is closely controlled. Film-surfaced metals offer many decorative effects because, along with the unlimited color possibilities of all four methods, the film may be embossed, "Spanished" or decorated some other way. Fluidized-bed coatings, which have the uniformity of solution coatings plus the thickness of plastisols, exhibit the appearance and feel of solid plastic rather than that of a coated metal. Also, by mixing colored powders, unusual marbleized effects can be achieved.

5. Substrate Limitations

All four techniques can be used for any of the commonly specified metals. The fluidizing technique, however, has limitations where application temperatures may be high enough to damage the substrate–particularly if it is less than 30 mils thick. Ferrous metals create no problems, but certain aluminum alloys may be annealed by the required preheat temperature which, for thin substrates, may have to be as high as 600 F.

The substantial thickness of plastisol and fluidized-

bed coatings can overcome surface irregularities better than solution coatings. Thus, a minimum of substrate grinding, polishing, filling, sanding, sealing or the like is needed.

6. Coatable Substrate Shapes

Solution coating here offers practically no limitations. Calendered film technique, on the other hand, is quite limited because only flat metal sheets can be surfaced—and the shape limits of sheetmetal forming apply here. Plastisols offer considerable difficulties with parts having intricate and finely detailed shapes or small openings; the high viscosity tends to "bridge" the coating and thus cover detail. Fluidized-bed coatings are better than plastisols in this regard but inferior to solution coatings because of the greater thicknesses and viscosities involved.

And Coating Costs?

Quantitative comparisons between the four techniques are hard to make because of the many factors involved in a specific application. However, the following practical generalizations apply.

Capital equipment for the three basic methods—solution, plastisol and fluidized-bed—will cost about the same (the main major investment being in ovens and associated handling equipment). Film coatings are usually applied by laminating specialists, since the technology is complex and equipment expensive.

Raw material cost per pound of solids can vary widely because there are so many different formulations. Generally, plastisols are at the low end, calendered film and fluidizing powders are in the middle, and the solution-coating materials at the high end.

Cost on a coverage or "per unit applied" basis is quite different, however. Here, the solution coatings are cheapest because thinner films are normally applied. Heavier coatings favor plastisols on this basis if the part to be covered is flat. For simple shapes involving little or no chance for sag marks, drips or "bridging," fluidizing will give a lower weight per part than will plastisols. The film-lamination method can lead to high scrap costs: Damaged parts or raw materials cannot be repaired by the user, and the parts are stamped from flat blanks.

Application costs are about the same per coat, for labor and overhead, on the three basic processes. Where multiple coats must be applied in the solution process to get desired thickness, cost will run in favor of plastisols and fluidized-powder coatings.

EDITOR'S NOTE: The following recent articles deal with various aspects of metal finishes—both functional and decorative:

"New Look in Porcelain Enamels," Nov 24 '58, p 53—covers latest unusual decorative finishes and shows how to consider engineering performance when making the selection.

"Magnetic-force Welding for Vinyl-clad Steel," Sep 15 '58, p 82—gives first data on weld strengths, welding arrangements, and ways to escape trouble with this new joining technique for metal-plastic laminates.

"Textured Steel," Mar 17 '58, p 73—full-color article shows when to use textured steel, how it's made, where it's applied, tips on design and fabrication, and trends.

"New Nylon Clads Sleeve Bearings," Mar 3 '58, p 52—shows how the fluidized-bed process combined with nylon-11 powder can make bearings with good moisture stability.

"Vacuum Coatings Go Industrial," Dec 23 '57, p 67—presents data on some of the new, thicker coatings that are taking vacuum deposition out of strictly decorative jobs.

"Pre-painted Steel," Dec 9 '57, p 99—staff article in color explains metal preparation, how to choose a paint, coating the steel, fabrication, assembly and trends.

"Hot-dipped Aluminum Coatings," Oct 28 '57, p 57—shows how aluminum hot-dipping, now easier, lets you substitute cheaper materials, lower fabricating costs and reduce maintenance.

"Color and Texture in Aluminum," Sep 30 '57, p 101—full-color article shows exceptional range of surface treatments—mechanical, chemical, and electro-chemical—plus some coloring treatments peculiar to aluminum.

"Fluidized Plastic Coatings for Corrosion Resistance," Jan '57, p 140—explains the mechanism of fluidized-bed method, coatings available, design and cost factors, and typical applications.

"Colored Finishes for Copper," Dec '56, p 135—Full-color article discusses natural finishes on copper and copper alloys obtainable through combinations of chemical conversion and mechanical treatment of surface.

"Vinyl Laminate," July '56, p 167—article describes film method of coating metal sheet with vinyl through use of adhesives.

Next Design Issue

ACOUSTOELASTICITY—

a new stress analysis method

Speed of sound transmission in a metal part is increased by compressive stress—but the effect is so slight it never occurred to anyone that the change could be used as a basis for nondestructive stress analysis.

Then two physicists at Armour Research, Dr R. W. Benson and V. J. Raelson, had an idea there might be some way to "polarize" the sound waves—as photoelasticity does with light waves—and then correlate phase change with stress. They found the way and then proceeded to develop equipment that shows magnitude of stress directly.

This new method now adds another important tool for nondestructive direct stress analysis with some advantages all its own over the basic photoelastic technique employing transparent models.

The researchers' first published account of their method is a feature article coming in the July 20 issue. It describes this significant development and shows how it can also measure residual or built-in stresses directly—in metals or nonmetals, and in actual parts and structures.

One Battle We're Losing —And Why

Lest it seem self-serving, we of McGraw-Hill, as publishers, have hesitated to make the following statement about the "Battle of the Books." However, our reticence has been overcome by our conviction that it is greatly in the national interest to have much wider public understanding of the nature of this battle. This conviction is strengthened by the fact that many, not in the publishing industry, believe in the importance of this battle and, further, by the fact that it is a battle which the United States is losing.

The United States is losing an important battle — a battle of knowledge and ideas, waged with books. It does not have the excitement of competition in scientific achievement, nor the urgency of a diplomatic crisis, nor the obvious economic significance of a struggle for export markets. But our success or failure in this battle of knowledge and ideas may well have a decisive bearing on these more spectacular aspects of international rivalry.

The Russians know this. About a decade ago, they started a program to build up their export of books, the most durable and penetrating way of communicating knowledge and ideas. **By 1957 the Soviet Union was exporting 30 million books, one-and-a half times as many as the United States.** Many of these books are printed in English, and all are in languages of the non-Communist world.

In the languages of the Near East alone, the Russians printed and distributed 413,600 books in 1957, as compared with 166,415 in 1956. In India, Russian textbooks on engineering are to be published in English under a technical aid agreement signed in Moscow last December.

"Trade Follows The Book"

Books are in the advance guard of the Soviet political and economic challenge to the free world. With books go ways of thinking — about government, about education, about management, about science and technology. If these books do their job effectively in the training of those who will become a nation's leaders, they will provide the basis for political and cultural understanding and also, in the future, for trade.

The Russians are not the first to discover this relationship. Britain, which lives by trade, has traditionally exported more of its book production than any other nation. Today it exports one book in every two produced. The British have a favorite dictum: "Trade follows the book." They have proved its accuracy. Now the Russians are trying to make this same principle serve their purposes.

Where does the United States stand in this competition for men's minds? In number of books, it trails far behind the Soviet Union — exporting roughly 20 million books, against the Russians' 30 million. As a proportion of our total output of books, our exports amount to only 10% — against Britain's 50%.

The Russians' Advantage

U.S. book exports have grown in the years since World War II, from approximately $11,000,000 in 1946 to $35,000,000 in 1958 (both figures excluding Canada). But in expanding book exports, the American publishing industry faces two major obstacles:

(1) **The comparatively high cost of producing a book in the United States,** which puts its price well beyond the reach of many students, teachers and businessmen in other countries; and

(2) **The shortage of dollar exchange in many countries,** which means that importers can pay for

books only in currencies that are of little use to American publishers.

The Russians have neither of these problems. Soviet publishing is state-subsidized, and exported books are sold for nominal sums paid in the currencies of the importers. As these books serve the political and economic purposes of the Soviet Union, they are cheerfully sold on giveaway terms.

The American publishing industry, on its own, is making vigorous efforts to increase the distribution of American books in other countries. Leading U.S. publishers and their agents have offices and salesmen in the major countries of Asia, Africa and Latin America. Several publishers have begun to reprint textbooks in Asia at one-half to one-third of their U.S. costs, thus making them available to the students in Asian countries at prices they can more nearly afford. And the American paperback has become a symbol of low cost in popular books. But neither of these devices is practicable for serious cultural, technical, scientific, educational and professional books, which require durable, hard-bound and necessarily expensive editions. Despite their great importance to those who need these books, the demand for them is simply not large enough to warrant low-cost publishing methods.

Government agencies also have increased the availability of American books. The United States Information Agency and the International Cooperation Administration have placed American books in libraries overseas, donated them to educational institutions and presented them to key individuals in the industries and governments of the developing countries of the world. But these programs are small in relation to the need.

A Modest Program

An unusual and little-publicized Government program has helped American publishers overcome the other major obstacle to the export of books — the shortage of dollar exchange. This is the Informational Media Guaranty (IMG) program, administered by the United States Information Agency. It enables publishers of books judged to be worthy of the American way of life to sell their books, for local currency, in countries such as the Philippines, Formosa, Vietnam, Burma, Indonesia, Pakistan, Turkey, Israel, Poland, Yugoslavia, Spain and Chile, which would otherwise be unable to buy these books because of their shortage of U.S. dollar exchange.

The IMG program is not a giveaway. Publishers have to **sell** their books, and customers overseas have to want them enough to **buy** them at full prices. IMG merely guarantees that the exporting publisher receives in dollars the payments he collects from his customers in their currency. The program costs very little in terms of our total foreign aid program, or in terms of what it accomplishes. In ten years it has made possible the sale of $150 million worth of books, magazines and films to countries of key economic and strategic importance at a cost of only $10 million.

The IMG functions through a revolving fund. Foreign currencies are exchanged for dollars, and the foreign currencies in turn are resold to replenish the supply of dollars. The net cost is the small but unavoidable loss on resale of these foreign currencies. Over the ten years of this program, the IMG revolving fund has shrunk from its original $28 million to $18 million, $10 million of which is in unconverted foreign currencies.

If this modest but vitally important program is to be continued, Congress must appropriate the money necessary to rebuild the revolving fund. This would ensure that any country approved by the State Department and willing to sign an agreement to buy American books, at their full price, with its own currency, could do so. Last August, Congress reduced a requested appropriation for this purpose from $7 million to $2½ million. To continue even at its present reduced level, an appropriation of $3½ million is needed. To realize the full potential of IMG, the revolving fund must be restored to its original level.

If the IMG program is not continued, with adequate financial support, some countries whose friendship and understanding we seek today and with whom we hope to build a trading partnership in the future will have to reduce their purchases of American books to a trickle. These are countries where school teachers, college professors, students, engineers, doctors and businessmen need and want to buy American books. The loss will be not only theirs, but ours as well. For it will deprive the U.S. of one of its most effective, and least costly, means of communicating knowledge and ideas and understanding of the American way of life.

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Donald C. McGraw

PRESIDENT

McGRAW-HILL PUBLISHING COMPANY, INC.

Here's the inside story of industry's

MOST RUGGED HIGH VOLTAGE SWITCH

THIS SOLENOID AIR BREAK CONTACTOR IS THE HEART OF THE A-B STARTER LINE

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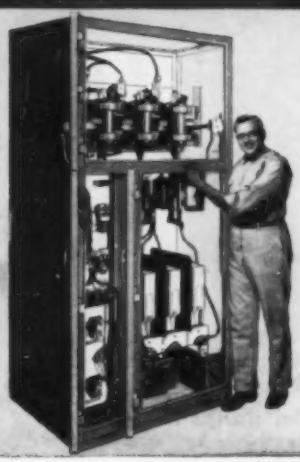

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Bulletin 1159 high voltage air break, across-the-line induction motor starter in NEMA Type 1 enclosure. All Allen-Bradley high voltage starters are equipped with current limiting fuses with interrupting capacities of 150,000 kva at 2300 v; 250,000 kva at 4600 v.

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CIRCLE NO. 75 READER SERVICE CARD 75

12 Clamps for FLEXIBLE HOSE

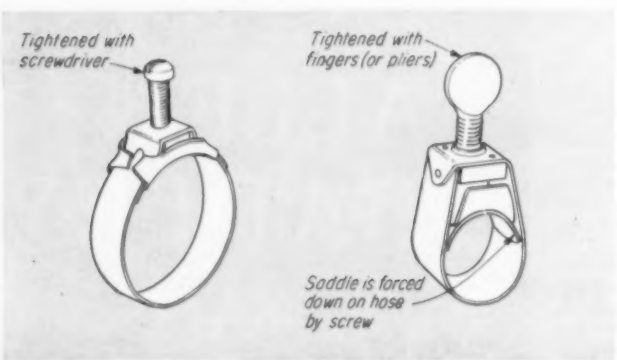
FRANK W WOOD JR, *design engineer, Vitro Labs, Silver Spring, Md*

Flexible hose of all types is used in a multitude of industries and products. One very familiar use is in the water-circulation system of an automobile. Other familiar examples are household appliances such as washing machines and dishwashers. Whatever the end-use of the hose may be, it must be connected so that it will pass liquid or gas without leaking at the joint between the hose end and member to which it is coupled.

There are many hose clamps commercially available that provide varying degrees of clamping action around flexible hose. The following sketches illustrate some of them. The typical leak-pressures shows what limitations exist in hose couplings.

Typical Leakage Pressures (Military tests)

Clamp size, in.	Hose ID, in.	Leakage Pressure, psi	
		20 in.-lb clamp-screw torque	40 in.-lb clamp-screw torque
3/4 and less	5/16 and less	600	600
13/16 to 61/64	3/8 to 1/2	470	600
61/64	1/2	350	600
1 5/64	5/8	280	350
1 7/32 to 1 15/32	3/4 to 1	235	350
1 15/32	1	175	350
1 45/64 and 1 57/64	1 1/8 and 1 1/4	150	300
2 1/64 and 2 9/64	1 3/8 and 1 1/2	150	300
2 25/64	1 3/4	125	250
2 41/64	2	125	250
2 29/32	2 1/4	100	200
3 5/32 and over	2 1/2 and over	100	200

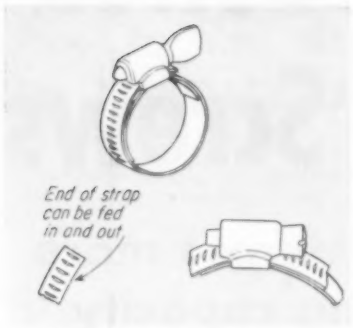


1 2

Radial clamp . . .
with slot-head screw (1) or wing-head screw (2) cannot be opened, must be "end-fed" onto hose. No loose parts is a feature of the second type.

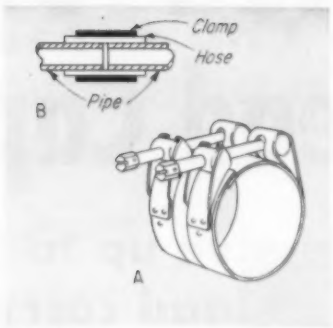
3

Tangential clamps . . .
may be opened to be "side-fed" onto hose by removing screw and nut.



4

Tangential worm-clamps . . .
have no loose parts, may be opened for installation after hose is in position. A 10-pitch buttress thread on a hardened steel screw is the general type of tightening-screw used.

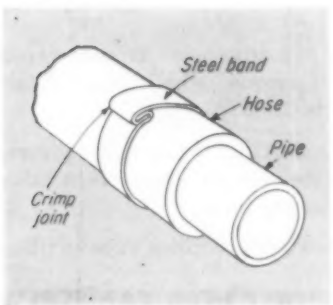


5

Dual tangential-clamp . . .
and coupling aligner—clamp length provides alignment for rigid members being coupled with flexible hose. In (A) hose acts as the aligner.

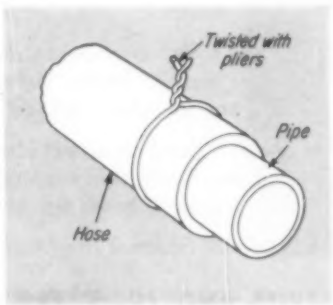
6

"Hook bolt" tangential . . .
clamp provides positive locking, easy removal. Wrench is necessary for tightening of clamp.



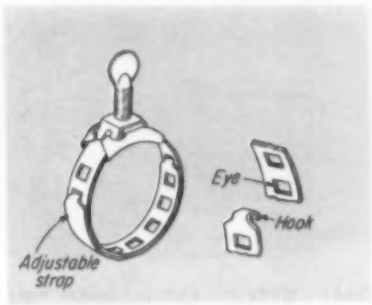
7

Machine-installed . . .
flat, crimped band is difficult to remove but gives good sealing action at relatively low cost, especially for production-line assembly.



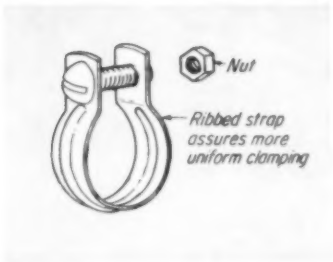
8

Twisted wire . . .
is recommended only for temporary emergency use—the wire will rapidly cut into the hose owing to "cold flow" of hose, and small bearing-area.



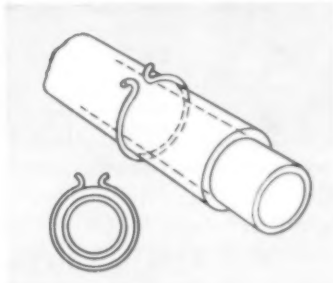
9

Radial clamp . . .
has large range of adjustment and may also be taken apart—into two "halves"—for easy assembly.



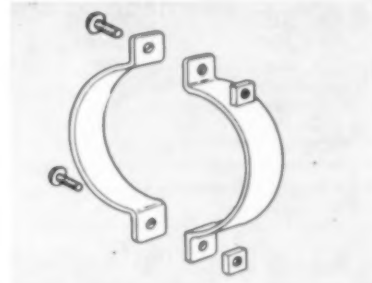
10

Open-band . . .
clamp is low cost and generally efficient so long as the open section is drawn close on assembly, otherwise leakage will occure where clamp does not exert pressure.



11

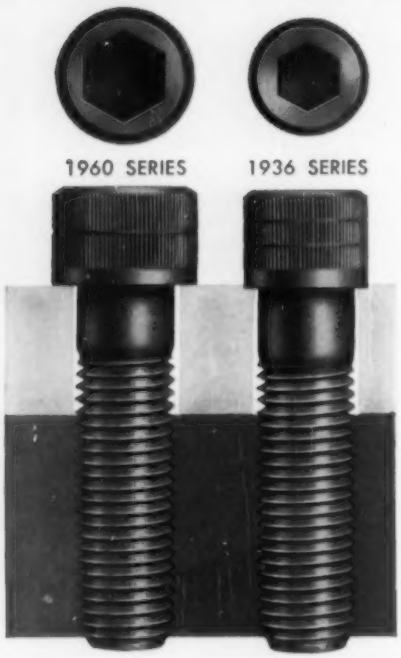
Constant-tension . . .
torsion-spring loop provides take-up to compensate for cold flow of hose. It is only suitable for relatively light-duty applications.



12

Two-piece . . .
clamp has objectionable, loose hardware, but is widely used for low-cost jobs. Ideal for "workshop" emergency clamping.

Allen's *New '60 Series* Socket Head Cap Screws



give up to 2⅓ times more load carrying capacity ...without indentation!

In Allen's new '60 Series, head diameter of sizes from ¼" up is now uniformly one and one-half times the body diameter. In many sizes (where this ratio was not called for by 1936 Series specifications) this will provide *more* under-the-head bearing surface, and a proportionate *increase* in clamping force. Loads are more evenly distributed, and the greater bearing area in many cases eliminates need for washers.

Socket sizes have been increased in many cases—greater wrenching area permits higher tightening torque—which resists fatigue failure, and lengthens the life of the threaded joint.

- A new 2-band knurl will identify all ALLEN Cap Screws (except Stainless Steel) that conform to the new '60 Series specifications. New labels on boxes will also identify these.
- The 1936 Series of Allen Cap Screws will continue to be available.

COMPARISON OF ALLEN 1960 SERIES AND 1936 SERIES SOCKET HEAD CAP SCREWS

SCREW SIZE	HEAD DIAMETER Minimum (inches)		BEARING SURFACE Minimum (square inches)		PERCENT OF INCREASE IN BEARING SURFACE[1]	TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)		TORQUE INDUCED TENSILE LOAD TO INDENT IN SOFT STEEL[2] (lbs.)	
	1960 Series	1936 Series	1960 Series	1936 Series		1960 Series	1936 Series	1960 Series	1936 Series
¼	.365	.367	.044	.044	—	4,750	4,750	2,780	2,780
5/16	.457	.429	.070	.052	33	7,440	5,600	4,380	3,300
⅜	.550	.553	.111	.111	—	12,100	12,100	7,000	7,000
7/16	.642	.615	.140	.103	36	15,000	11,000	8,850	6,450
1/2	.735	.739	.183	.183	—	19,500	19,500	11,500	11,500
5/8	.921	.863	.293	.216	35	31,000	23,200	18,500	13,600
¾	1.107	.987	.424	.224	89	45,000	24,000	26,700	14,100
⅞	1.293	1.111	.585	.253	131	62,500	27,000	36,800	15,900
1	1.479	1.297	.768	.405	89	82,000	43,500	48,500	25,500

[1]Head tolerance revisions on Sizes #0 thru #10, ¼, ⅜, and ½ diameter have no significant effect on bearing surface or holding power of screws.

[2]Values based on .00025 inch indentation.

Ask your Industrial Distributor about ALLEN '60 Series Cap Screws.
Write for samples and complete specifications. Ask for Bulletin G-25.

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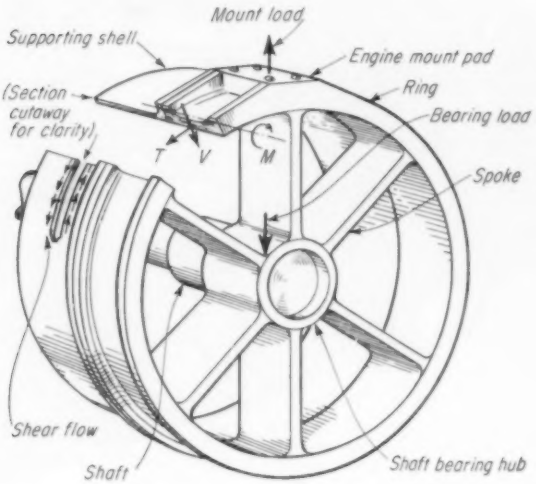
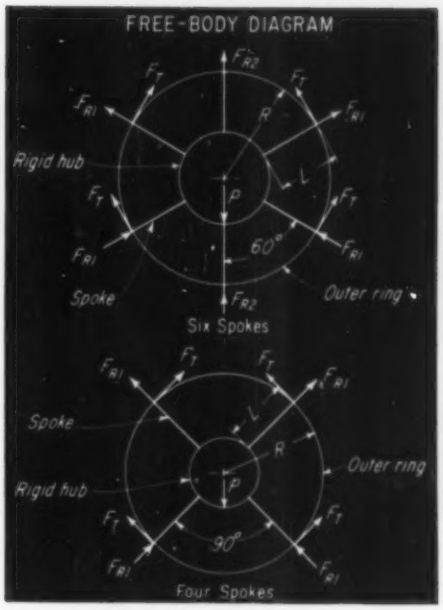
ALLEN HEX-SOCKET SCREWS HEAD

How to find stresses and deflections in SPOKED BEARING-SUPPORTS

LAWRENCE BERKO, *supervising design engineer*
Walter Kidde & Co Inc, Belleville, NJ



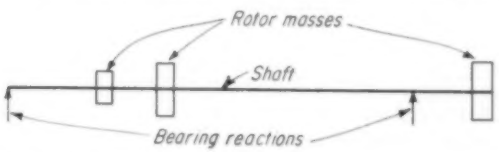


Accurate analysis of stresses and deflections in a spoked support leads to lighter weight design. It also helps critical-speed analysis of shaft systems in such applications as gas turbines; support housings for large air-cooling fans; electric motor casings slotted at the ends for air-cooling passages. The 6-spoked support is most widely used, but curves for 4-spoked supports are also included here.

In all calculations for spoked bearings the rings are assumed supported by sinusoidally varying tangential skin-shear reactions. Spokes are also assumed pinned to ring but rigidly attached to the hub.

EXAMPLE:

A shaft and 6-spoked bearing system has three rotor masses. Because of "g" loading, or perhaps gyroscopic loading, bearing reactions are developed. These loads



acting at the hub of the bearing support are designated by P; if the material and geometry of the support are specified, the following data would be known:

P = 10,000 lb (at either bearing)	L = 10 in.
I_S = 25 in.^{4}	R = 12 in.
I_R = 0.3 in.^{4}	C_S = 3.5 in.
A = 7 in.^{2} (for ring also)	C_R = 0.40 in.
$E_S = E_R = 10 \times 10^6$ psi	

(CONTINUED ON PAGE 81)

SYMBOLS

A = spoke cross-section area, in.^{2}
C_S = distance, neutral axis to extreme fiber (of spoke), in.
C_R = distance, neutral axis to extreme fiber (of ring), in.
E_R, E_S = elasticity moduli (ring and spoke), psi
R_{R1} = axial loading in inclined spokes, lb; (+ for upper two, − for lower two)
F_{R2} = axial loading in vertical spokes, lb; (+ for top, − for bottom)
F_T = tangential load at OD of inclined spokes, lb; (clockwise on left side, counterclockwise on right side)
I_R = outer-ring moment of inertia about neutral axis perpendicular to plane of support, in.^{4}
I_S = spoke moment of inertia about neutral axis perpendicular to plane of support, in.^{4}
k = spring rate with respect to outer shell, lb/in.
L = spoke length, in.
M = max bending moment (6-spoked support) in outer ring at OD of vertical spokes, in.-lb; (+ at inner-fiber upper point and outer-fiber lower point)
= max bending moment at OD of all spokes in 4-spoked support
P = bearing radial-load, lb
R = ring radius, in.
T = axial loading in outer ring at OD of vertical spokes in 6-spoked support; all spokes in 4-spoked support (− at upper points, + at lower points)

+ denotes tension
− denotes compression

PowerGrip FLEXIBLE COUPLING

GEARED FOR TOP EFFICIENCY AT LOWEST COST

Actual size #42 PowerGrip Flexible Coupling—2 hp. at 1750 rpm., 72 in./lbs. maximum torque. Also available up to 40 horsepower, at 1750 rpm. and torque loads up to 1440 in./lbs.

U. S. PowerGrip Flexible Coupling

- Compensates for greater angular and axial misalignment.
- Installed in minutes by eye. Horizontal or vertical application. No precise measurement required.
- Requires no lubrication, operates silently.
- Eliminates end thrust and shaft vibration.
- Machinery failure cannot harm equipment. Eliminates equipment damage due to overload or jam-up. The coupling disengages itself and can be instantly and inexpensively replaced.
- Costs less, requires no maintenance.

• • •

Your U. S. Power Transmission Distributor has a full stock of all sizes of U. S. PowerGrip Flexible Shaft Couplings. He is your best on-the-spot source for technical aid, quick delivery and quality industrial rubber products.

Mechanical Goods Division

United States Rubber

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Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

BEARING-SUPPORTS (CONTINUED)

1. Find value of M by calculating

$$\left(\frac{I_S}{I_R}\right)\left(\frac{R}{L}\right)^3\left(\frac{E_S}{E_R}\right) =$$

$$\left(\frac{25}{0.3}\right)\left(\frac{12}{10}\right)^3\left(\frac{1}{1}\right) = 144$$

From "M" curve in chart for 6 spokes:

$$\frac{100M}{PR} = 1.45$$

$$M = \frac{1.45\,PR}{100} = \frac{(1.45)\,(10{,}000)\,(12)}{100}$$

$$= 1740 \text{ in.-lb}$$

2. Find T from same chart:

$$\frac{10T}{P} = 1.55$$

$$T = \frac{1.55P}{10} = \frac{(1.55)\,(10{,}000)}{10}$$

$$= 1550 \text{ lb}$$

3. Total stress in outer ring, at top vertical spoke:

$$M(C_R/I_R) + \frac{T}{A}$$

$$= 1740\,\frac{(0.4)}{(0.3)} + \frac{1550}{7}$$

$$= 2320 + 220 = 2540 \text{ psi}$$

4. Total stress in one of the inclined spokes is found from the F_{R1} curve in same chart for the same parameter (144):

$$\frac{10F_{R1}}{P} = 0.82$$

$$F_{R1} = \frac{0.82\,P}{10} = \frac{(0.82)\,(10{,}000)}{10}$$

$$= 820 \text{ lb}$$

also

$$\frac{10F_T}{P} = 1.47$$

$$F_T = \frac{(1.47)\,(P)}{10}$$

$$= \frac{(1.47)\,(10{,}000)}{10} = 1470 \text{ lb}$$

5. Bending moment in the spoke, at the hub, is $(F_T)(L) = (1470)(10) = 14{,}700$ in.-lb. $= M_s$
Total stress at this section is

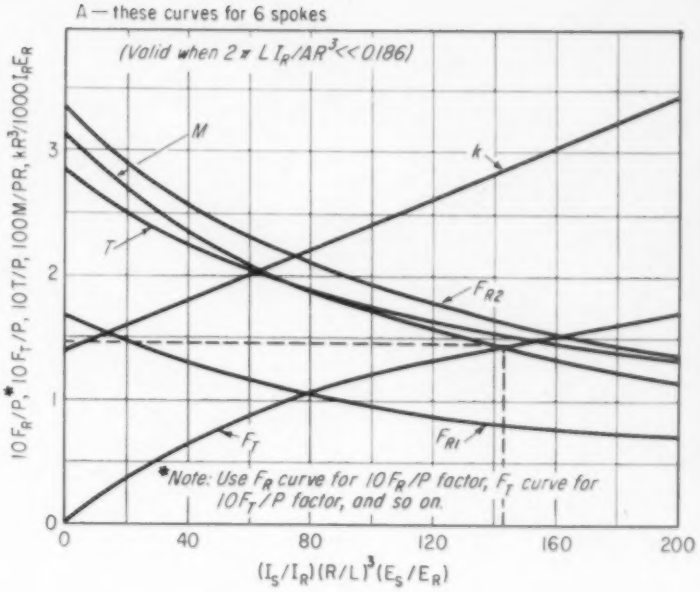
$$M_S\left(\frac{C_S}{I_S}\right) + \frac{F_{R1}}{A}$$

$$= (14{,}700)\,\frac{(3.5)}{25} + \frac{820}{7}$$

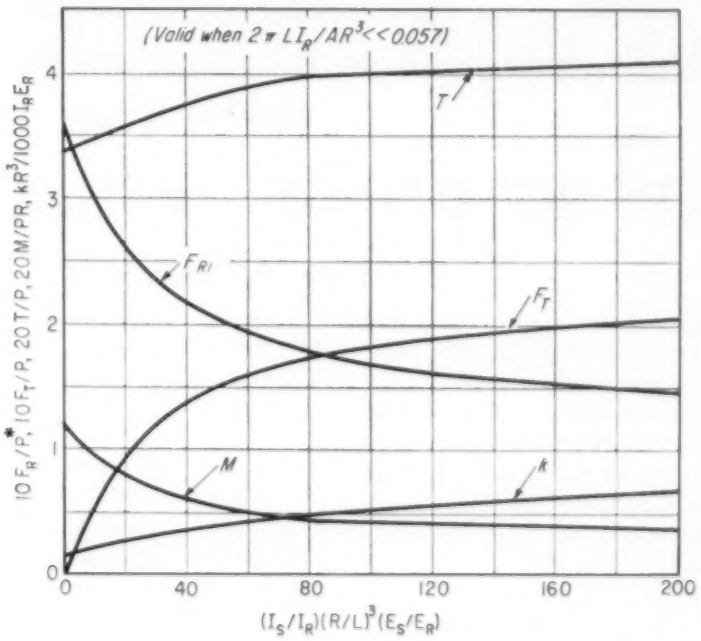
$$= 2060 + 120 = 2180 \text{ psi}$$

6. To determine spring rate of the spoked bearing support (for 144 parameter),

A — these curves for 6 spokes



B — these curves for 4 spokes



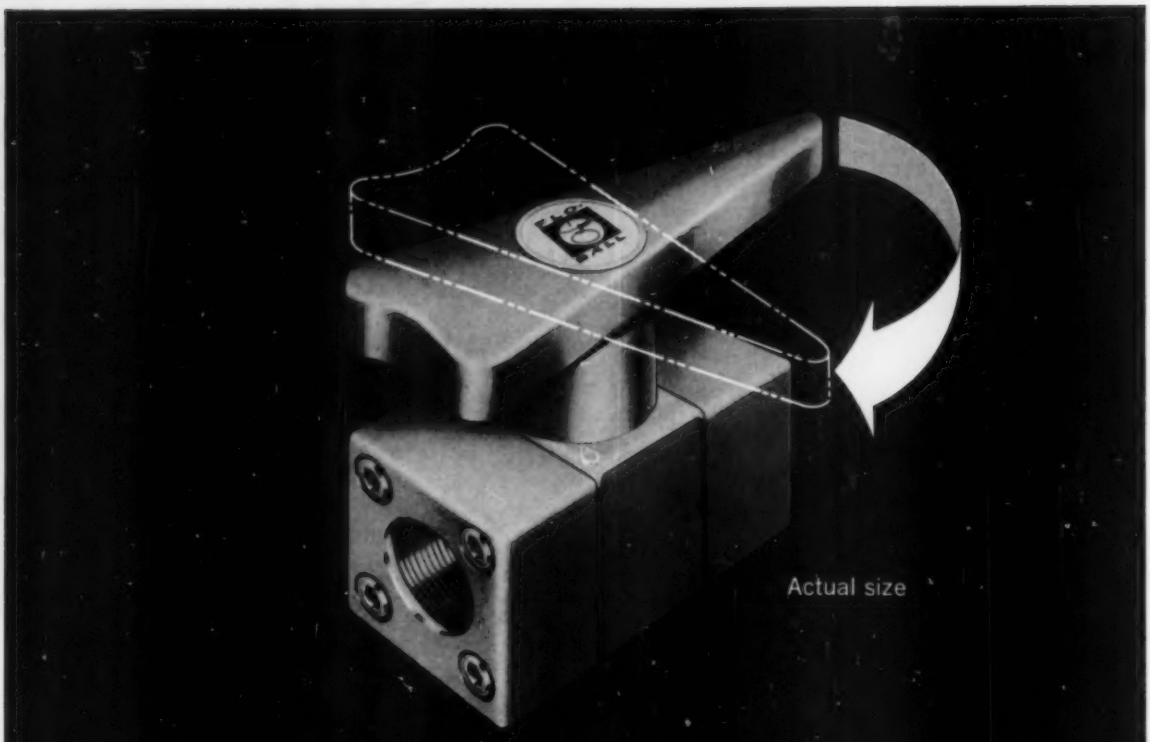
$$\frac{kR^3}{I_RE_R} = 2850, \text{ whence}$$

$$k = \frac{(2850)\,I_RE_R}{R^3}$$

$$k = \frac{(2850)\,(0.3)\,(10)\,(10^6)}{(12)^3}$$

$$= 4.93 \times 10^6 \text{ lb/in.}$$

From this spring rate, the bearing deflection caused by shaft masses can be easily found. To this deflection add the actual shaft deflection. This gives total deflection for the shaft system. The usual analysis for critical speed of the shaft system under examination may now be made.



Replace obsolete needle valves with the NEW 90° ON-OFF *FLO-BALL*

For 3,000 PSI...

Low torque, instant action . . . a fast 90° turn, requiring just 4 inch-pound torque at 3,000 psi, actuates the valve instantly!

Priced no higher than needle valves!

100% flow efficiency . . . straight-thru ***FLO-BALL*** design has more than twice the flow efficiency of needle valves!

Positive ON-OFF indication . . . large arrow-shaped handle shows valve position at a glance!

Zero leakage . . . Mass Spectrometer tests with Helium prove zero leakage!

Universal mounting . . . can be panel, side, bottom, or line mounted!

Removable flanges . . . damaged flanges can be removed in seconds; no need to replace entire valve!

All stainless steel construction . . . costs no more than old fashioned screw-type valves!

Versatile service . . . ideal for leakproof control of air, vacuum, steam, water, fuels, oils, kerosene, alcohol, and many other fluids.

SERIES 715			
Port Styles and Sizes			
NPT		AND10050	
Size	Part No.	Size	Part No.
⅛	715A1	¼	715A2
¼	715B1	⅜	715B2

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FLO-BALL

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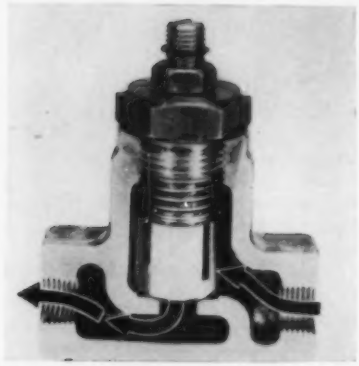
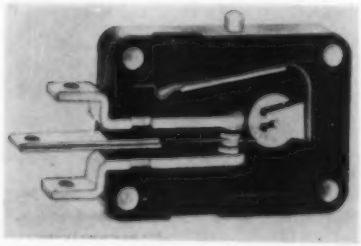
LIVINGSTON, N. J. • WYMAN 2-4900 • TWX=LIVINGSTON, N. J. 120

SIGNIFICANT COMPONENTS MATERIALS PROCESSES



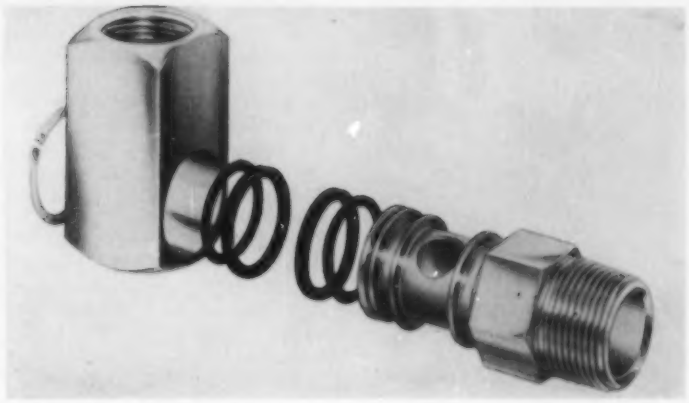
Control valves use poppet . . .
with four varied-length orifices, instead of needle-type control, to permit micrometer adjustment of exhaust-air flow from zero to full pipe capacity. Positioning of adjusting stem controls total orifice area. For pressure air, poppet lifts off seat, permitting unrestricted full-pipe capacity air flow. Buna-N seat on poppet is said to provide positive seal and eliminate wear. Locknut on stem locks adjusting stem. Valve series is said to be self-cleaning with wiping action that prevents dirt clogging and does not change setting. ¼-in. valve is $6; ⅜-in., $7; ½-in., $8; ¾-in., $9; 1 and 1¼ in., $19. From stock. **Automatic Valve Co, 37415 Grand River, Farmington, Mich.**

Circle 300, Reader Service Card



Cam-actuated snap switch . . .
is said to withstand over 30 million mechanical actuations and over 250,000 electrical actuations. When pressure is applied, button or plunger causes spring-loaded wheel carrier to move wheel axis. When axis moves into line with contact arm, toggle action occurs and contact moves to opposite position. Operates under vibration to 20 g max, over frequency range of 10 to 4000 cps. $1.30 each. Delivery, 1 to 2 wk. **Torres Engineering Co Inc, South Hackensack, NJ.**

Circle 301, Reader Service Card

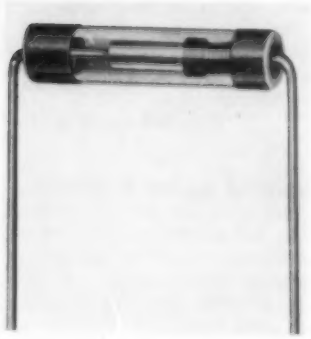


90° swivel connector . . .
delivers hydraulic fluid at any angle under adequate pressure, relieving extreme flexing strain that was formerly absorbed entirely by hose. Since connector absorbs part of swing, less hose allowance is said to be necessary for complete extension of moving part and stiffer, longer lasting multiple-spiral wire hose can be used. Low torque operation and freedom from friction are reported at pressures up to 5000 psi. Interior design causes body to float around stem, free of end load or friction. Fluid pressure is absorbed equally by double seal at end of stem. Various stems can be interchanged with any body style. Bar-steel ends immediately available include male pipe, hydraulic male, O-ring male, plus solid and swivel female, in sizes from ½ through 1½ in. Plated for corrosion protection. OEM price, about $5 each. **Eastman Mfg Co, Manitowoc, Wis.**

Circle 302, Reader Service Card

Permanent-mold casting process . . .
utilizes high, but controllable, rate of heat transfer from mold and calculated amount of feed metal to produce castings said to be essentially stress-free and to possess high physical and mechanical properties. Increased properties are attributed to greater homogeneity of material and controlled grain size. Parlanti Mold Process, which may be used to cast high-temperature metals and many types of exotic metals, as well as aluminum, magnesium and steel, makes possible casting of many parts that formerly had to be made by other means, such as forging. Company handles production orders and is now licensing foundries in various parts of country. **Niforge Corp, 677 Beacon St, Boston 15.**

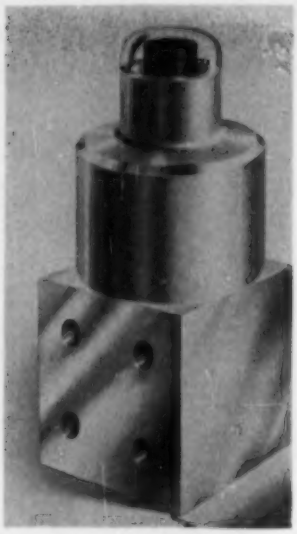
Circle 303, Reader Service Card



Temperature-sensitive fuse . . .
fires at predetermined ambient temperatures. Miniature thermal protective device will handle up to 15-amp continuous current over temperature range of −65 to 200 F. Circuit opens when nominal temperature of 281 F is reached. Internal resistance is less than 1 milliohm at 15 amp. Other models have variations of firing temperatures and current-carrying capacities. Fuse measures 0.285 in. dia. x 1¼ in. long and is hermetically sealed. Price depends on specs. **Networks Electronic Corp, 14806 Oxnard St, Van Nuys, Calif.**

Circle 304, Reader Service Card

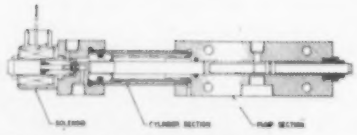
. . . CONTINUED ON PAGE 84



Reusable shock indicators . . .

detect and give visual indication if a predetermined permissible limit has been exceeded. Primarily for use in shipping of delicate parts or instruments, detection devices are said to have complete spherical sensitivity. Units are also available with one- or two-plane sensitivity with reported accuracy of 5% of preset value. Standard models may be preset for 5 to 75 g. Meet typical military environmental specifications. Reusable indicators, with life expectancies of about 5 yr, are resettable and protected against tampering with inspectors' seals. **Inertia Switch Inc, 311 W 43rd St, New York 36.**

Circle 305, Reader Service Card



Pneumatic metering pump . . .

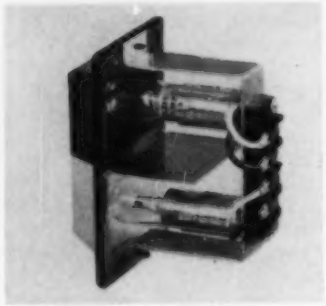
is infinitely adjustable within capacity range of 0 to 6.44 cc. Unit consists of solenoid-actuated pneumatic cylinder and pump head that contains inlet and outlet ports and provision for precise limitation of stroke length of air cylinder piston. Check valves are not integral, so they may be placed in inlet and outlet lines if necessary. Said to be capable of precision metering of even heavy-bodied liquids, since pumping pressure can reach 354 psi. Pumping pressure is determined by air pressure, up to 200 psi, and air cylinder bore, 1, 1¼ and 1½ in. Air ports are ¼ in.; cylinder stroke is 0 to 2 in.; fluid line connections are ¼ in. Solenoids are available for most ac or dc voltages. **Airmatic Valve Inc, 7313 Associate Ave, Cleveland 9.**

Circle 306, Reader Service Card

Alkyd molding compound . . .

is glass-fiber-reinforced for applications where flame resistance, strength, moldability and high electrical properties are desirable. Classified as an MAI-30 material, covered by Military Spec MIL-M-21699. Free-flowing material is also applicable where delicate inserts are used. Produced and packaged in continuous rope form in diameters from ¼ to 1¼ in., in light tan and colors. Readily molded by compression transfer and plunger methods. Fast cure and short cycles permit use in high-production applications. Said to have excellent dimensional stability and moisture resistance, high arc resistance and dielectric properties at both power and communication frequencies. Typical uses are in electrical parts such as circuit breakers, switch housings, terminal boards and connectors. **Glaskyd Inc, 234 Eckel Rd, Perrysburg, Ohio.**

Circle 307, Reader Service Card



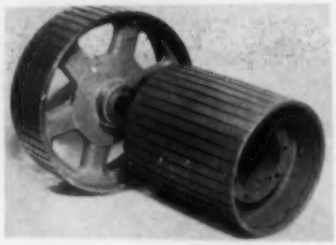
3-dimensional turret lenses . . .

for panelboard indicating lights, which can be used individually at random or in groups, are available in various color combinations for two-light indication or a single color for top and bottom portions for single-light use. Said to afford increased visibility from any angle, with illuminated area of 2¼ x 3 in. Light frame assembly may be used with flat backlighted engraved nameplates, 2-color split flat lenses or as a 2-color bull's-eye light, all interchangeable. Entire assembly is self-contained and includes lenses, mounting frame, light baffle, lamp support bracket, sockets, two 6-w lamps and terminals. Requires single cut-out of 2¼ x 3 in. **Tigerman Engineering Co, 4332 N Western Ave, Chicago 18.**

Circle 308, Reader Service Card

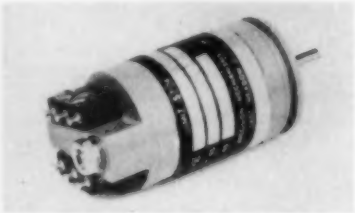
Grooved pulley surface . . .

is said to prevent entrapment of air between belt and pulley surface and to offer less slippage, longer belt life and quieter operation without use of belt dressings. Flat-belt pulleys may be used in any flat-belt power transmission, but are particularly adaptable to short center distances



and where intermittent machine loads are encountered. Pulleys from 3½ to 16 in. dia and in various widths up to 12 in. to fit standard QD hubs are carried in stock. Fixed bore types are also available. **Republic Engineering & Mfg Co, 611 S Snelling, St Paul 16.**

Circle 309, Reader Service Card



Adjustable limit switch-stop . . .

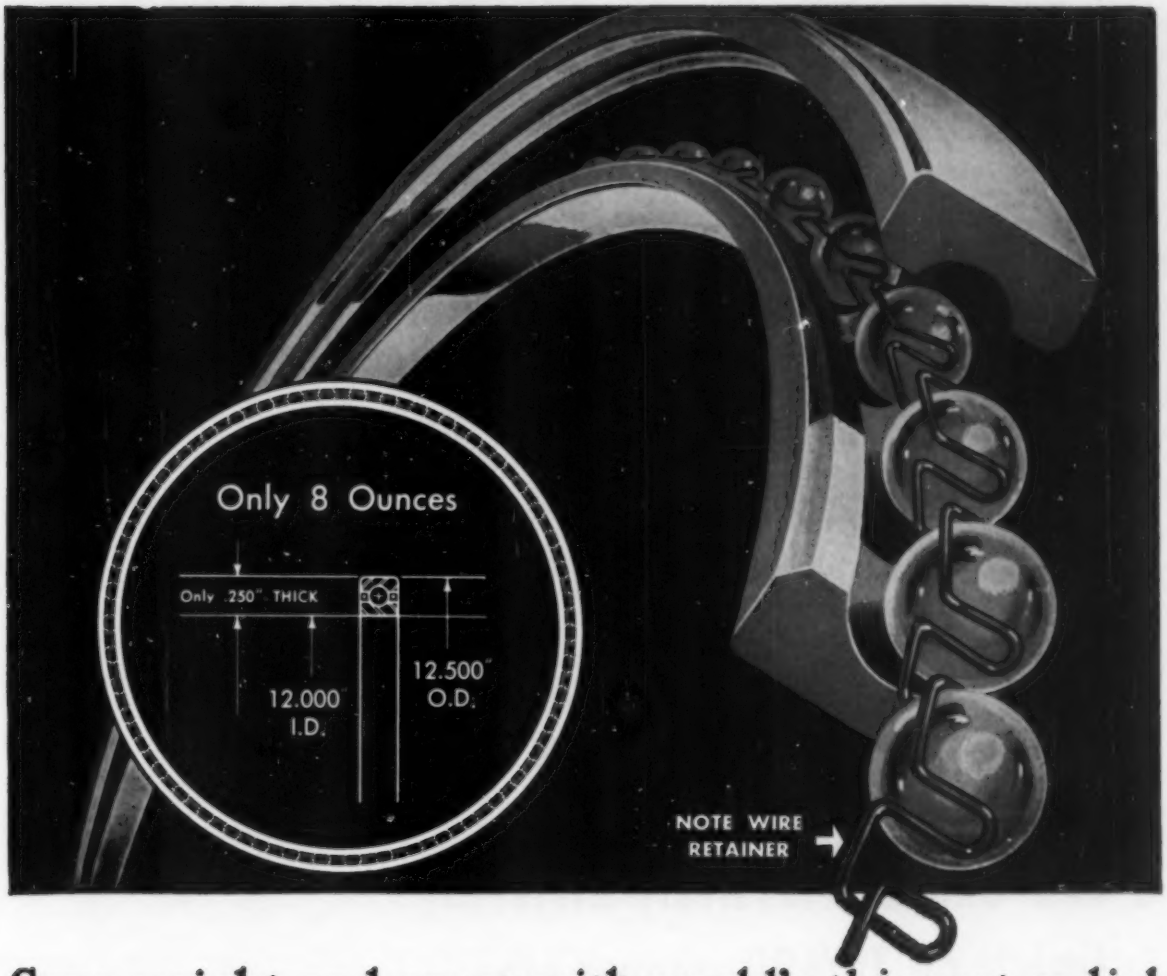
for servo and instrument applications has single exterior screw that permits infinite adjustment to any angular rotation from zero to 25 turns. Limit switches are actuated at either end of shaft travel, just prior to contact with nonlocking limiting stops. Dimensions are 0.937 in. dia x 2 in. overall. Shaft is 0.125 in. dia. Features include torque capacity of 40 in.-oz at end stops, low operating torque and low inertia. Constructed of corrosion-resistant steel and anodized aluminum alloy. Conforms to applicable sections of MIL-E-5400. **Precision Mechanisms Corp, 577 Newbridge Ave, East Meadow, NY.**

Circle 310, Reader Service Card

Eddy-current dampers . . .

are self-contained, nonfriction, nonhydraulic units to control such undesirable forces as overtravel motions, oscillation, force surges and unstable speeds. Model 1054 has damping rate of 40 in.-lb/rad/sec and inertia of 0.033 slug ft². Peak input velocity is 4 rad/sec; breakout torque is 1 in.-lb max; backlash is ½° max. Weighs 2.8 lb. Unit has externally adjustable overload protective clutch with torque setting of 40 in.-lb + 10 to 20-in.-lb. Model 1103 incorporates an electrically operated brake to lock input shaft to any desired position within 360° rotation. Permanently lubricated damping mechanism has damping rate of 1000 ±50 in.-lb/rad/sec up to 0.20

. . . CONTINUED ON PAGE 86



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon ...now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

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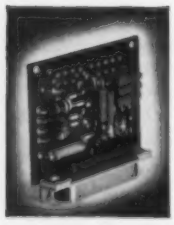
All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

Now! A higher reliability factor in printed circuits

ALTORI

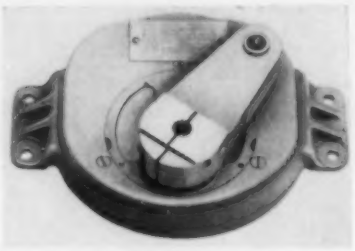
a new and distinctively different finish on TAYLOR copper-clad laminates that accepts all acid resists uniformly



Something new and distinctively different has been added to TAYLOR copper-clad laminates — a finish that accepts all types of acid resists uniformly. High fidelity in printed circuit reproduction is assured. Circuits can be of consistently higher quality and reliability, no matter how critical the design. For complete details about TAYLOR copper-clad laminates and samples, write TAYLOR FIBRE CO., Norristown 39, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE



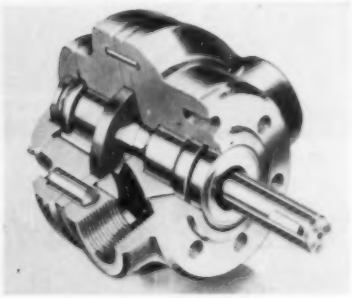
rad/sec; inertia of 0.64 slug ft²; peak input velocity of 0.74 rad/sec; breakout torque of 2-in.-lb max; backlash of 0.1° max. Weighs 5 lb. Both models have 360° rotation and operate within normal temperature range of —65 through 165F. **Lyndon Aircraft Inc, 140-71 Clifford St, Newark 5, NJ.**

Circle 311, Reader Service Card

Standard extrusions . . .

as well as custom shapes are available in rubber, synthetic rubber, silicones or special compounds for a wide variety of applications. **Pacific Moulded Products Co, 905 E 59th St, Los Angeles 1.**

Circle 312, Reader Service Card



Pumps handle fire-resistant . . .

fluids where fire hazards make use of hydraulic oils dangerous. Hydraulic pumps were tested with proprietary water-soluble oil emulsions, both regular and inverse; ethylene glycol-water mixtures; phosphate ester types and high-temperature MIL fluids. Dimensionally interchangeable with regular oil-hydraulic units of comparable capacities. Currently available from stock in 3, 5, 8 and 12-gpm sizes in QDH-830 single pumps or combinations of these in QGH-H-830 double pumps; 20, 30 and 40-gpm sizes in OG-860 single pumps. **Double A Products Co, Sub of Brown & Sharpe Mfg Co, Manchester, Mich.**

Circle 313, Reader Service Card

Leaded carbon-steel tubing . . .

fabricated from C-1020 analysis steel to which 0.15 to 0.35% lead has been added is said to increase machinability from 72 to 85 or 90% and cutting speeds from

(Continued on page 90)

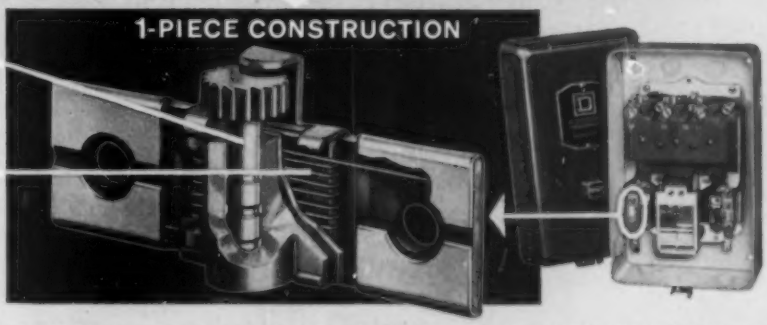
When you buy Motor Starters--

YOU PAY FOR OVERLOAD PROTECTION

...BE SURE YOU GET IT!

Heat-responsive element (solder pot) provides accurate response to overload, yet prevents nuisance tripping.

Heat-producing element is an integral part of overload unit. It's permanently joined to solder pot, can't become misaligned.



Only ONE-PIECE Overload Relays can give 100% Protection Only with ONE-PIECE construction can you *know* you've installed the heater correctly. Only with ONE-PIECE construction can you *know* the heater is exactly centered, or properly positioned, so that it performs according to its rating. Only with ONE-PIECE construction can you *know* your starters will not operate without the thermal units properly installed. Only with ONE-PIECE construction can you *know* your motors have full protection.

Only Square D has ONE-PIECE Construction ONE-PIECE construction *eliminates* any possibility of heater misalignment. Square D melting alloy thermal overload relays can be installed only one way. They are tamper-proof. They are factory-assembled, are *individually* calibrated and tested. Repeated tripping will not affect their accuracy.

Insist on Square D starters with melting alloy thermal overload relays

Let your Square D Field Engineer show you 1 how one-piece construction is accomplished and how easy it is to mismatch separate heaters and solder pots— 2 an endurance tester to prove that overload units can be reset repeatedly without damage while the solder is liquid — 3 a tripping time tester to compare various types of melting alloy units and to prove that tripping time won't change after repeated operation.

Individual factory inspection of every Square D melting alloy thermal overload relay means performance you can trust. Each unit is calibrated and thoroughly tested to make sure it will perform according to its rating.

Write for Bulletin SM-275 for the complete story on Square D starters with ONE-PIECE thermal overload relays. Address Square D Company, 4041 N. Richards St., Milwaukee 12, Wisconsin

SQUARE D COMPANY

Cold Bonderite Earns Supplier of the Month Award for Parker

DETROIT, MICH.—The Parker Rust Proof Company, pioneer manufacturer of surface treatments for metals, was named "Supplier of the Month" by the Home Laundry Department of General Electric Company in a ceremony at Louisville April 20.

The award and citation were presented by R. J. Keyser, Manager of Manufacturing of the Home Laundry Department of General Electric Company, to R. W. Englehart, President of Parker Rust Proof Company.

Basis of the award, according to the citation, was the performance of Cold Bonderite, installed in the finishing system on recommendation of Parker engineers. The material substitution in three phosphate units resulted in a considerable savings per year in steam costs and has also lowered the ambient temperatures of the paint enclosures in a very positive way. This material, an exclusive product developed by Parker Rust Proof Company, was installed without additional cost in materials, investment or labor.

Everybody's enthusiastic about Cold Bonderite! Since its introduction a year and a half ago, over one hundred plants have installed this revolutionary new system. Cold Bonderite System solutions operate at temperatures 40° to 75° below temperatures in conventional systems, saving important sums in heat costs, maintenance and equipment.

Cold Bonderite can be a winner in your spray finishing line, too! Call in the Parker man right now.

Since 1914—leader in the field

Parker Rust Proof Company

2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE corrosion resistant paint base	BONDERITE and BONDERLUBE aids in cold forming of metals	PARCO COMPOUND rust resistant	PARCO LUBRITE—wear resistant for friction surfaces	TROPICAL—heavy duty maintenance paints since 1883

*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

3 NEW BELLOWS DEVELOPMENTS FROM Flexonics

new FLEXONICS Hastelloy* alloy B bellows— to strong chemicals

FLEXONICS new Hastelloy alloy B bellows open new opportunities to the designer for efficient, dependable control of flow and pressure of certain highly corrosive media. For example Hastelloy alloy B is well suited to handle hydrochloric acid at all concentrations and temperatures, including the boiling points, and has good resistance to sulphuric and phosphoric acid, hydrogen chloride gas, as well as many other severely corrosive media. The metal is similar in strength and ductility to alloy steel. FLEXONICS Hastelloy alloy B bellows can be supplied in sizes from 13/32" I.D. to 5-3/4 I.D.

*Registered trade mark Union Carbide Corporation

new miniaturized FLEXONICS bellows... nominal 5/32" I.D.

Seamless, hydraulically formed precision bellows in a wide range of metals and performance characteristics. Exceptional strength . . . and extreme sensitivity to temperature and pressure changes as a result of light wall thickness.

new FLEXONICS miniaturized flexible couplings from stock

As small as 15/32" O.D. in various metals. Transmit rotary motion with absolute zero backlash . . . minimize bearing wear and friction. Direction of rotation may be reversed without loss of action. Accommodate shaft sizes 1/8" to 5/16" diameter.

For design applications that involve the measurement of pressure or temperature . . . a flexible sealer . . . or even low-torque power transmission — a Flexonics Bellows can be your answer. Send an outline of your bellows applications — the Flexonics Application Engineering Staff will be pleased to make recommendations. If you prefer write for the Flexonics Bellows Design Guide . . . 20 pages of valuable information.

B-505

TOMORROW'S ENGINEERING TODAY

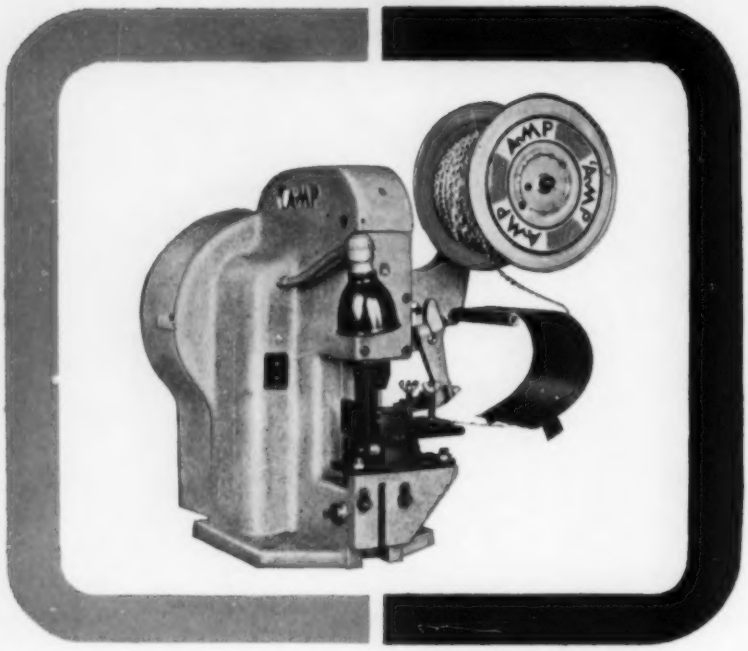
Flexonics BELLOWS

FLEXONICS CORPORATION • 1351 SOUTH THIRD AVENUE • MAYWOOD, ILLINOIS

Divisions
INDUSTRIAL HOSE • EXPANSION JOINT • BELLOWS • AERONAUTICAL • AUTOMOTIVE
Flexonics Research Laboratories, Elgin, Illinois
In Canada: Flexonics Corporation of Canada, Limited, Brampton, Ontario

FASTER

THAN YOU CAN SAY "CIRCUIT TERMINATION BY AMP"



Speed—amazing speed—is fundamental with AMP's tool-and-terminal technique. In fact, an A-MP automachine can turn out 4,000 terminations per hour.

No extensive operator training is required. And, no large floor space—the bench-mounted Automachine takes up less space than an ordinary desk. It's built for safety, built for speed, built for reliable production day after day. And A-MP Automachine terminals are made in a size and shape to fit every requirement with such features as corrosion resistance, vibration resistance, and, if required, pre-insulation. Furthermore, actual costs of the AMP method are lower than any other method.

Why not learn more about this world famous compression-attachment method? Send for our descriptive literature.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

120 to 140 or 150 surface fpm. No noticeable difference is reported in physical and mechanical properties between leaded and nonleaded C-1020. Furnished in seamless form in sizes from 0.012 to 1⅛ in. OD. **Superior Tube Co, 1556 Germantown Ave, Norristown, Penna.**

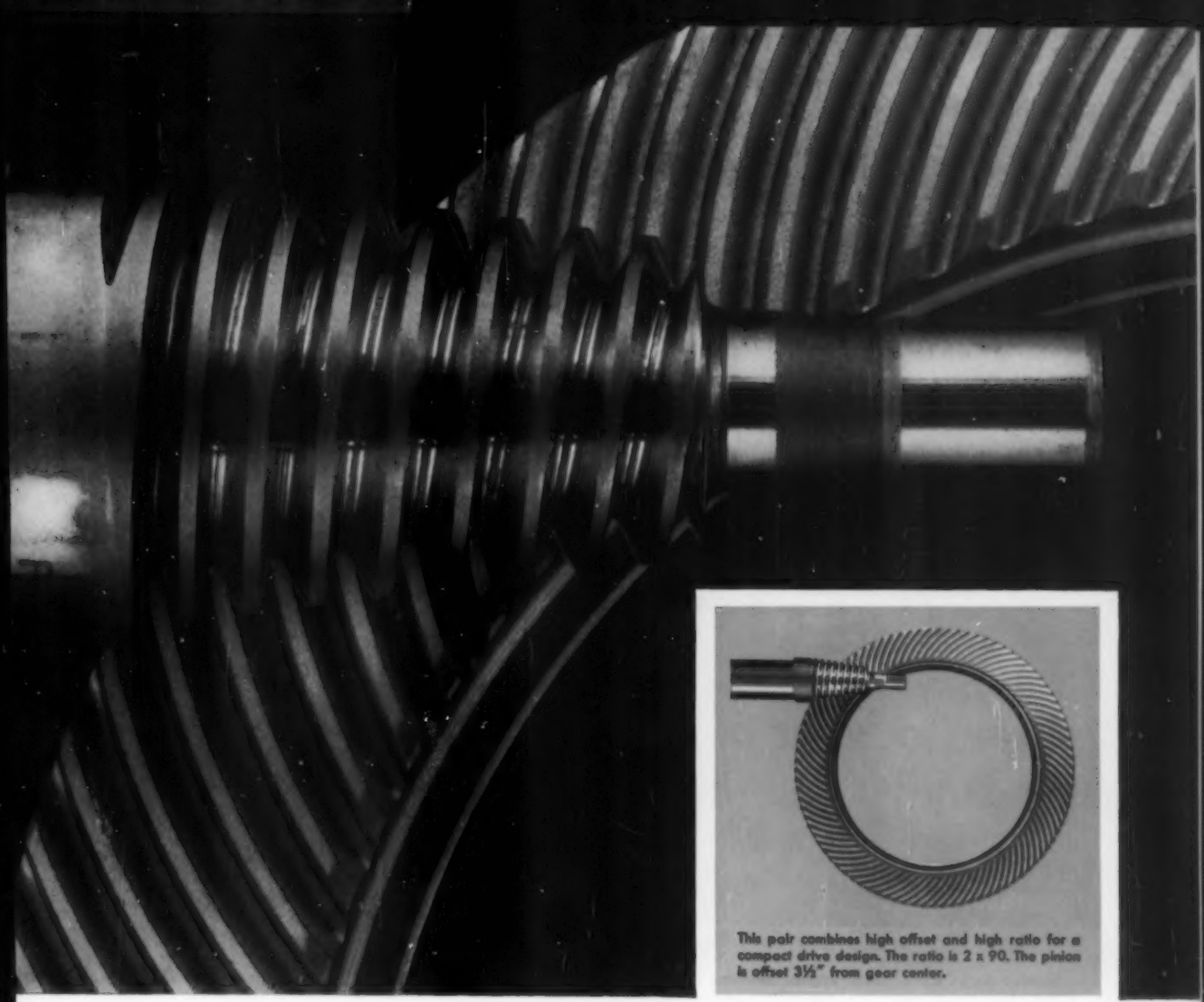
Circle 314, Reader Service Card

Automatic engine controls . . . encased in steel, dustproof cabinet, incorporate overload breakers that eliminate fuses and plug-in relays to simplify field maintenance. In closing cover, cushion pressure locks relays in sockets. An engine equipped with automatic control can be started or stopped from remote pilot devices, such as pressure switches, float switches or power failure relays, and are completely automatic in operation. **Synchro-Start Products Inc., Skokie, Ill.**

Circle 315, Reader Service Card

Miniature solenoid valves . . . in 2- and 3-way direct-acting types have brass or stainless steel bodies. Line features ac shading coils of fine silver, fully rotatable coil housing for electrical connections from any angle, ability to operate equally well in any mounted position and a broad selection of pipe and tube connections. Considered to be among smallest solenoid valves currently available, they average several ounces less in weight than comparable units. Orifice sizes for 2-way types range from 3/32 to ⅛ in. with differential pressure ratings as high as 2000 psi. Three-way types have orifice sizes from 3/32 to 1/16 in. with differential pressure ratings to 300 psi. Two-way units are available in normally open or closed designs; 3-way types also include universal flow pattern. Coils, for continuous duty, are Class A or H for varying temperature applications. Windings are designed in accordance with UL requirements for op-

(Continued on page 94)



This pair combines high offset and high ratio for a compact drive design. The ratio is 2 x 90. The pinion is offset 3½" from gear center.

See how the teeth "wrap around" this high-reduction pinion

This is a high-ratio hypoid gear. In principle, it is not different from more conventional hypoids produced by the Gleason Works. *But . . .*

If you look closely at the pinion, you'll notice that the teeth tend to "wrap around" it. This design is extremely well suited for high reduction, strength and compact design.

The result is a conical (or sometimes cylindrical) pinion which permits *continuous tooth action—even with just one or two teeth!* Compared to corresponding bevel pinions, its diameter is greater for higher strength. An extended shank on cylindrical pinions makes *very rigid* straddle mountings practical.

You can design a *compact* unit, because high offset is possible! For high-offset *or* high-ratio pairs, the "wrap around" tooth design provides an extra measure of the smooth, quiet tooth action of hypoid gears.

High-ratio hypoids can be cut on the same Gleason equipment that is used on more familiar spiral bevel gears and hypoids. You can also use the same testers, quenching presses and other auxiliary Gleason equipment you're using now. Grinders are available for applications requiring precision finish.

High-ratio hypoids can be produced by the Gleason Works for ratios of 1:10 or 1:40 or even higher. They are finding a growing number of applications in such diverse fields as farm machinery, instrumentation and office equipment.

You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

CIRCLE NO. 91 READER SERVICE CARD

MT. VERNON DIE CASTINGS help STANLEY develop stronger, lighter, tougher heavy-duty builders' saws

CASE HISTORIES FROM MT. VERNON FILES

Stanley packs more power into its new line of low-cost, heavy-duty saws . . . and saves important weight doing it! They have been designed for greater utility, with such features as: Ball bearing guard — fingertip depth-or-bevel setting, uncluttered front — window brush-holder for simpler servicing, extra handling comfort, positive control, etc. Yet, with all these improvements, Stanley is still able to sell these better saws for less!

A big reason for this lower cost is Mt. Vernon's coordinated four-fold die casting service: designing, die-making, casting and machining. Mt. Vernon worked closely with Stanley* to create light, thin-walled aluminum castings with strength to spare. All parts are produced with excellent surface finish to facilitate barrel burnishing. Many fit together without machining thereby contributing to lower manufacturing and assembly costs.

Stanley is typical of the leading manufacturers in the power tool industry who know and rely on Mt. Vernon's experience and facilities for die cast zinc and aluminum parts. As the largest independent die casting company — with over 200,000 square feet under one roof — our services and equipment are ready to help solve your design and production problems. We'll be glad to discuss the advantages of die castings with you at any time. Just call your nearest Mt. Vernon sales representative.

*Stanley Electric Tools, New Britain, Conn.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

DIE CASTING RESEARCH FOUNDATION PARTICIPANT

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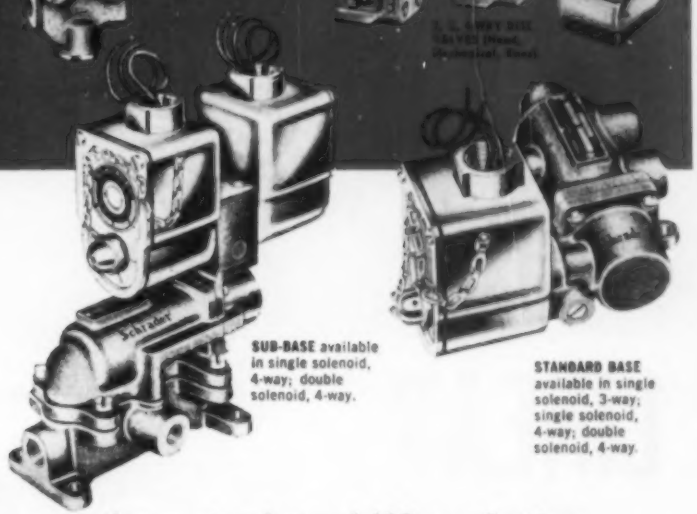
ALL THESE... *full lines from Schrader...*

AND NOW...

NEW JIC SOLENOID AIR VALVES

..... that meet and exceed JIC specifications



SUB-BASE available in single solenoid, 4-way; double solenoid, 4-way.

STANDARD BASE available in single solenoid, 3-way; single solenoid, 4-way; double solenoid, 4-way.

New JIC Solenoid Valves are compact, rugged, fast-and-easy to install. Roomy junction boxes fit space requirements with 90° rotation. Can be operated in case of current failure, by hand. Safe, recessed override button prevents accidental operation. Electrical system completely sealed against dust, oil.

Schrader's complete line of air valves allow you a freer hand in planning air circuits for your applications. Besides almost unlimited choice of size, style and actuation method, you get these extras in every Schrader valve you buy:

- All parts are designed for maximum air flow, longest service life; simplicity of replacement; interchangeability.
- Schrader Valves feature tough, practical design, precision construction, and are individually tested to full ratings.
- Performance has been proved by years of use in hundreds of plants. All Schrader Valves can operate with Schrader (JIC) Square End Cylinders perfectly.

Use the full Schrader line to do your air control selecting. Your Schrader distributor can help you pinpoint what you need. For more data write:

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Division of Scovill Manufacturing Company, Incorporated
477 Vanderbilt Avenue, Brooklyn 38, N. Y.

Schrader®
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QUALITY AIR CONTROL PRODUCTS

by

LINEAR

in low-compression-set Butyl . . . for sealing problems involving the non-flammable phosphate esters.

LINEAR . . . specialists in close tolerance molding in all of today's elastomers.

Call on LINEAR for assistance with all your seal problems.

"PERFECTION IN RUBBER"

LINEAR

LINEAR, Inc. STATE ROAD & LEVICK ST., PHILA. 35, PA.

erating at 10% over and 15% under rated coil voltage. **Hoke Inc, 197 Piermont Rd, Cresskill, NJ.**

Circle 316, Reader Service Card

More hydraulic hp output . . .

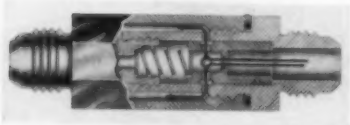
is said to be produced by new vane pumps for operation at up to 2000 rpm and pressures to 2000 psi. Three models deliver 52, 63 and 75 gpm at 2000 rpm 2000 psi. At 1200 rpm 100 psi, delivery is 34, 41 and 48 gpm with same units. Pumping cartridges are field replaceable in 10 min. without removing pump from mounting. Hydraulic balance is reported to eliminate pressure-induced bearing loads. Features include simplicity of construction and automatic wear compensation. The 4-position cover facilitates installation. Inlet can be rotated in 90° increments with respect to outlet; 4-bolt SAE flange connections will also accommodate user's 2-bolt flanges of proper design. **Vickers Inc, Div of Sperry Rand Corp, Detroit 32.**

Circle 317, Reader Service Card

Constant-flow regulator . . .

provides flow rate of 1.7 gpm ±3% for fuels and oils, regardless of differential pressures from 10 to 2000 psi. In ⅜-in. line size, unit will handle operating pressure to 3000 psi; proof pressures to 4500 psi. Operates in temperatures of −65 to 350 F. Can be manufactured in other line sizes to handle variety of flow volumes and modified for tight flow tolerances, other differential ranges and temperatures to 700 F. **Aero Supply Mfg Co Inc, Corry, Penna.**

Circle 318, Reader Service Card



Pressure transducers . . .

are offered in seven pressure ranges from 0-50 to 0-5000 psi, in gage and differential types, for use with fluids or gases. Electromechanical devices are said to produce high degree of accuracy in sensing and transmitting proportional ac voltage directly to readout equipment and servo controls. Two variable-reluctance models include temperature-compensated unit (to 0.01%/° F) with 50 milliv/v/fs sensitivity and unit with 100 milliv/v/fs sensitivity. Linearity for both is 1%. Input voltage at 400 cps is 10 v ac optimum to 24 v ac maximum. Impedance is 300 to 1000 ohm and natural mechanical frequency is 5 to 20 kc, depending upon range. Withstands overloads to 150%

(Continued on page 98)

Locking screws with LOCTITE increases production 23%

Assembling Hobbs Hour Meters

Mr. LeRoy L. Rasch
John W. Hobbs Div., Stewart-Warner Corp. Springfield, Illinois, says:

"We all try to cut costs. For example, we used a resin-type product to hold screws in assembling Hobbs Hour Meters. It was necessary for a girl to dip a little piece of wire into the compound, transfer it to the screw hole, and then assemble the screw. With 18 screws this was a slow and tedious job. We switched to LOCTITE Sealant and increased production while making the job easier for the girls. Operators now produce 23% more meters per hour thanks to LOCTITE! This increased production is accomplished by tumbling large batches of screws with LOCTITE in a polyethylene bag. The screws, treated and ready, are spread in front of the operator within easy reach. LOCTITE will not harden in air, but sets firmly when screws are assembled. LOCTITE saves us time and money by virtually eliminating the labor of applying the staking compound to the screws. LOCTITE cut costs for us with no effort at all."

LOCTITE is a thin liquid that hardens when confined between closely fitting metal parts. One drop replaces all size lock nuts, lock washers, lock screws, staking, jam nuts and interference threads. It forms a tough heat and oil resistant bond that resists any amount of vibration . . . yet ordinary tools will remove fasteners. LOCTITE requires no heating or mixing . . . treated parts can be stored for days . . . lock only when assembled. Write for literature and free sample.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY

119 Woodbine St., Hartford 6, Conn.

Hoover announces 3L00 extra light bearings

Now, America's quality bearings come in compact proportions designed to save space! Hoover's new 3L00 series extra light ball bearings provide the solution to bearing problems calling for maximum bore size and minimum housing area. They have outer diameter and width dimensions that are substantially smaller than those of standard light, medium or heavy series bearings of equal bore size.

Hoover 3L00 extra light ball bearings are available in a wide range of popular sizes in open, shielded and sealed types, including lubricated-for-life bearings with Hoover-developed contact seals of TEFLON. For complete information, return the coupon below.

Hoover quality is outstanding!

Micro-Velvet balls are made of selected high-carbon chrome alloy steel, uniformly hardened, and finished so perfectly that roundness and diameter are accurate within millionths of an inch.

Hoover Honed raceways, on both inner and outer rings, are super-smooth, superbly finished. Precision matching of ball complements and raceways assures hushed quietness, long life, superior Hoover performance.

Micro-Velvet and *Hoover Honed* are Hoover trademarks. TEFLON is a DuPont trademark for its fluorocarbon resins.

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Sales Offices and Warehouses: 2020 South Figueroa, Los Angeles 7, California | 290 Lodi Street, Hackensack, New Jersey

PE-7

Hoover Ball and Bearing Company
5400 South State Road, Ann Arbor, Michigan

Please send new Bulletin 108, which describes Hoover 3L00 extra light bearings.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

DESIGN FOR SMOOTHER, QUIETER MARINE PERFORMANCE

Bonded water pump impellers maintain high pumping efficiency. Specially compounded elastomers assure long life despite severe flexing and abrasion.

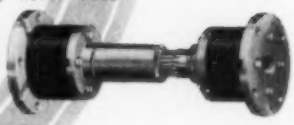
Inboard engine mountings provide low-cost, easy-to-install protection from damaging vibration and shock.

Outboard engine mountings, isolate engine and propeller vibrations, noise, power impulses. Dynaflex mounting systems contribute to "quiet" operation.

Bonded slip clutches protect outboard engine components against damage caused by propeller striking underwater objects.

WITH
Lord Vibration Control

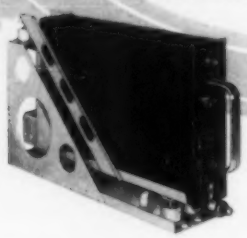
Flexible couplings transmit up to several thousand horsepower smoothly, efficiently, attenuate noise, accommodate misalignment, never need lubrication.



Mounting assemblies for diesel engines in power and utility craft isolate vibration and noise.

Electronic mounting systems are custom-designed to protect communications, navigation and guidance equipment in surface and sub-surface craft.

Seat mountings used in sheer seat suspensions introduce cushioned ride and greater passenger comfort.



What is your design objective?
Quieter operation? Less maintenance? Cost savings?
Improved personnel comfort? Fewer component failures?

You can utilize LORD capabilities in vibration/shock/noise control to realize these and other performance advantages for your marine equipment. LORD-engineered systems isolate undesired disturbances, enabling you to obtain vital competitive advantages.

For authoritative assistance on vibration/shock/noise problems, consult LORD. Contact the nearest Field Engineering Office or the Home Office, Erie, Pa.

LORD

FIELD ENGINEERING OFFICES

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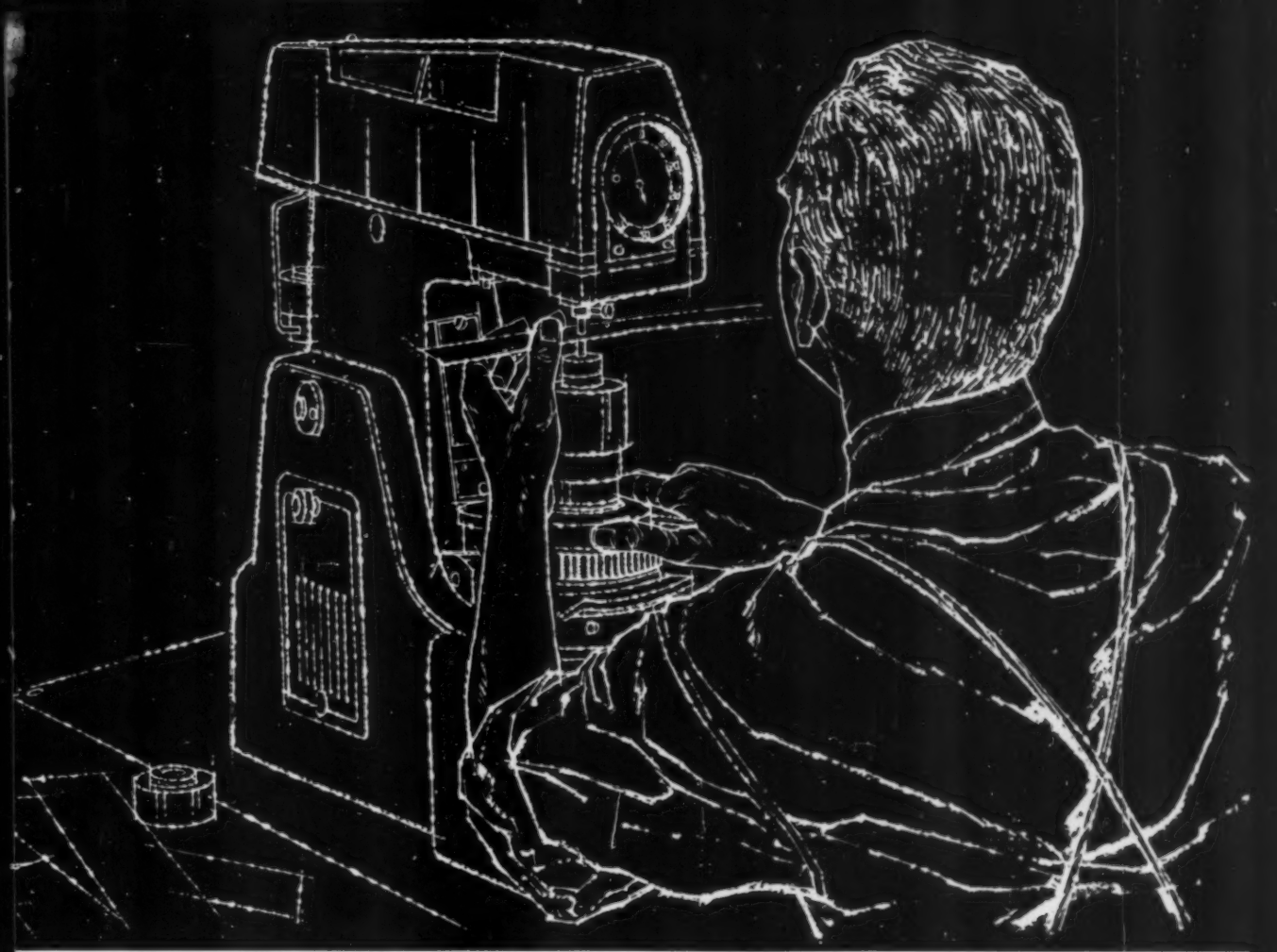
"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY · ERIE, PA.

CIRCLE NO. 97 READER SERVICE CARD→



PRECISE HARDNESS CONTROL

to your specifications with

J&L Cold Rolled Strip Steels

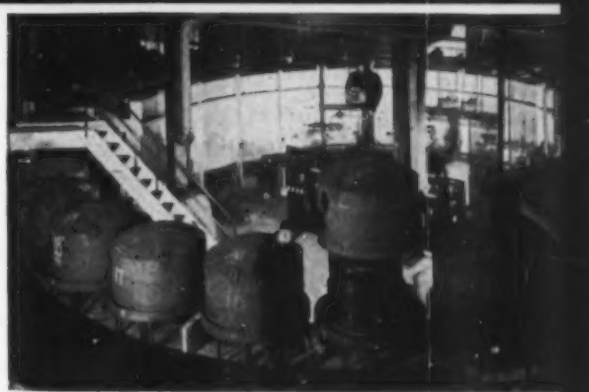
Variations within standard commercial limits of hardness for strip steels may not provide the quality needed for most critical applications.

At J&L the newest equipment and techniques are used to provide controlled hardness—to your specifications.

Basic oxygen converters, high standard open hearth practice and electric furnaces provide optimum melting conditions, new hot strip mills are specifically designed to produce the finishing temperatures needed for inherent quality. Cold mills, annealing and normalizing furnaces and other equipment are designed specifically for precision strip steel processing.

With an organization experienced in specialized strip steel processing, your most rigid specifications can be met consistently.

For your convenience, precision strip facilities are available to you in our plants at Youngstown, Indianapolis, Los Angeles and Kenilworth (N. J.)



The small unit rotary annealing method assures precision temperature control and develops optimum hardness and microstructure for high carbon, low carbon and alloy strip.

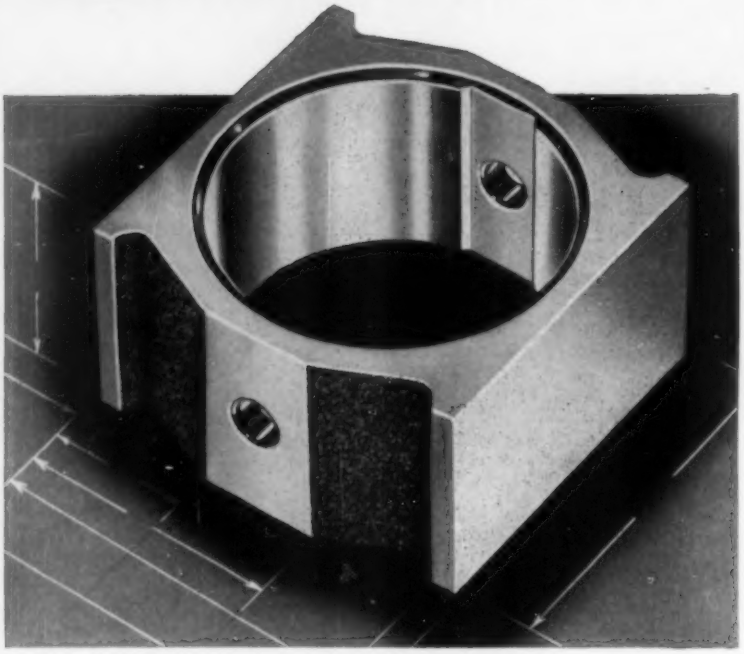
J&L

STRIP

LOW CARBON • HIGH CARBON • ALLOY • STAINLESS
TEMPERED SPRING STEEL • ZINC AND COPPER COATED

Jones & Laughlin Steel Corporation • STAINLESS and STRIP DIVISION • Youngstown 1, Ohio

many difficult requirements...



We illustrate the cast bronze cam block for a hydraulic pump operating the hydraulic lift mechanism on an exceedingly well-known line of farm tractors.

The manufacturer of this equipment has very unusual specifications for this cam block. Its bore has a very fine finish specification. It also must be round and true to size within unusually close limits. In addition, it must be square to the face of the cam block within limits that ordinary methods of manufacture will not attain.

Bunting methods of manufacture result in a part which is completely to the customer's exacting specifications.

For the unusual, as well as the usual, in bearings, bushings, bars, or special parts of cast bronze, sintered metal, or Alcoa aluminum, see Bunting first.

BUNTING SALES ENGINEERS in the field and a fully staffed Product Engineering Department are at your command without cost or obligation for research or aiding in specification of bearings or parts made of cast bronze or sintered metals for special or unusual applications.

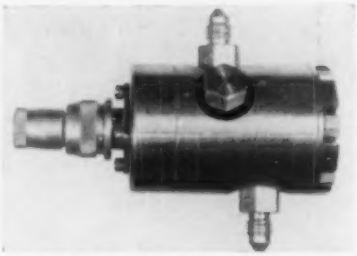
...ask or write for your copy of...

Bunting's "Engineering Handbook on Powder Metallurgy" and Catalog No. 58 listing 2227 sizes of completely finished cast bronze and sintered oil-filled bronze bearings available from stock.

Bunting®

The Bunting Brass and Bronze Company
Toledo 1, Ohio—EVergreen 2-3451
Branches in Principal Cities

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE OR SINTERED METALS. ALCOA® ALUMINUM BARS



of full scale and line pressures to 10,000 psi. Location of ports provides interchangeability of fittings at 60,120 and 180° and for bleeder valves when liquids are used. Weight is 16¼ oz. **Crescent Engineering & Research Co, 5442 N Peck Rd, El Monte, Calif.**

Circle 319, Reader Service Card

High-torque brake motor . . .

for start-stop operations in drives and positioning systems can be wound for 115 or 200 v ac, 60 or 400 cps in hysteresis-synchronous or induction types. Intermittent torques to 12 in.-oz are attainable. Electromechanical brake has epoxy-potted coil wound for any desired voltage to 100 v dc. Diode in circuit can provide dc power. Brake holding force is 10 in.-oz; engagement time is 40 to 50 millisec. Can be actuated by energizing or deenergizing coil. Brake motors are 1,675 in. dia x 2.750 in. long and weigh 17 oz. Units meet approximately MIL specifications. Said to be particularly applicable for anti-backlash stopping. **Globe-Industries Inc, 1784 Stanley Ave, Dayton 4, Ohio.**

Circle 320, Reader Service Card

Panel-mounted voltmeter . . .

has frequency range of 20 cps to 250 kc, extending about 150 kc higher than previous models. Accuracy is said to be 2% of full-scale deflection over entire frequency range. Input impedance of 5 megohm, paralleled by 25 $\mu\mu$f, is reported to enlarge ability to measure voltage without loading circuit being metered. Multivoltage range instrument is comparatively unaffected by line voltage variations.

(Continued on page 100)

S.S.White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

More Savings with Ready-to-Attach S. S. White Standard Flexible Shafts

NEW, EXTRA-HEAVY-DUTY SHAFT ADDED TO "OFF-THE-SHELF" LINE

Here's a time and money saving idea... the majority of flexible shaft needs can be met with ready-to-attach S. S. White **standard** flexible shafts.

This line has been recently expanded by the addition of the .500" dia. standard shaft to handle extra-heavy loads.

Flexible shafts allow you to simplify design ... position controls and driven parts to best advantage... eliminate expensive gears, universals, rods and costly alignment problems.

S. S. White **standard** flexible shafts are low in cost and readily available because they are **stock** items. They save you engineering time because the designing has already been done for you by S. S. White, first name in flexible shafts. **They come complete and ready to attach directly to your mating spindle.**

Another plus! Convenient, low-cost, readily available, S. S. White standard flexible shafts are the ideal way to test the advantages of flexible shafts in your products.

Where to use S. S. White Standard Flexible Shafts

REMOTE CONTROL of valves, actuators, switches, indicators and other mechanical or electrical equipment. S. S. White standard remote control flexible shafts come in four different shaft diameters to handle a wide range of requirements.

POWER DRIVE for an endless variety of applications ... portable tools, instrument drives, machine tools, pumps ... anywhere the designer needs to transmit power around obstructions or to movable parts, by means of a single, self-contained, easily applied unit. Four standard sizes.

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FIRST NAME IN FLEXIBLE SHAFTS

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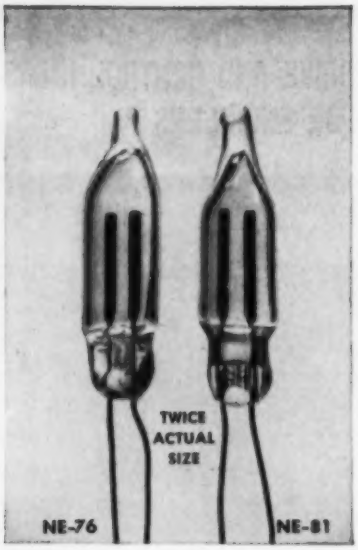
10 East 40th Street, New York 16, N.Y.
Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

Selection of S. S. White standard flexible shafts: complete description and application data available. Write for bulletin 5601.

WRITE FOR COMPLETE DATA!

Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. Write for bulletin 5601.

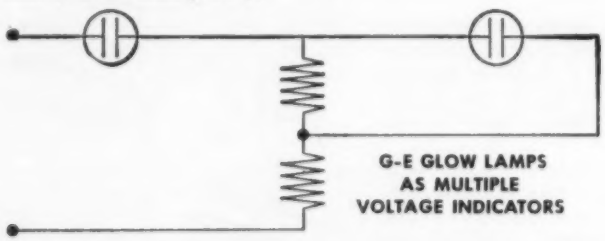
Here are two G-E Glow Lamps that have critical starting voltages



Two components of predetermined and stable characteristics for your circuit designs

G-E NE-76—Pre-aged, stabilized glow lamp has closest starting voltage tolerances of any General Electric Glow Lamp (±4-volts d-c). Same tolerance is held on operating voltage. G-E NE-76 will perform well in: Switching circuits, logic matrices, gating circuits and similar applications. The leads are plated for easy soldering and the lamps are treated by the G-E Dri-film process for high leakage resistance in humid areas. A *red dot* near the anode lead indicates polarity.

G-E NE-81—Similar to the G-E NE-76—has slightly wider starting voltage tolerances (±8-volts d-c). Has plated leads to permit easy soldering and the G-E Dri-film process insures maximum leakage resistance under high humidity conditions. The same mild radioactive additive used in the NE-76 is used here to reduce dark effect. A *white dot* near the anode lead indicates this glow lamp's polarity.



DIRECT CURRENT CHARACTERISTICS

	NE-76	NE-81
Starting Volts	72 ± 4-volts d-c	72 ± 8-volts d-c
Operating Volts	57 ± 4-volts d-c	50 to 60-volts d-c
Extinction Volts (in series with .25 megohm or more)	50-volts d-c	50-volts d-c
Design Current	0.4 m.a. d-c	0.3 m.a. d-c
Leakage Resistance (at high humidity)	100 megohms	100 megohms

NE-76 Life To stay within above specifications for at least 1,000 hours when operated at 0.4 m.a.

NE-81 Life Change in Starting and Operating Voltage At .3 m.a. + 5-volts in 6,000 hours

For further information write for free booklet entitled "Glow Lamps as Circuit Control Components", General Electric Co., Miniature Lamp Dept. M-901, Nela Park, Cleveland 12, Ohio.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Change of 10% in line voltage causes readout error of no more than 1% of full-scale deflection. The 6-in. meter is self-contained and has built-in power supply. **Metronix Inc, Chesterland, Ohio.**

Circle 321, Reader Service Card

Electromagnetic clutch . . .

is said to offer as much as 400% increase in output torque over clutches of comparable size. For friction face models, output torque is 80 in.-oz min at 24 to 28 v dc. Breakaway torque is 0.15 in.-oz energized and 0.05 in.-oz deenergized. Max weight is 13.5 oz. General specifications include zero backlash and zero to 0.0003 in. end-play max. Fungus-resistant insulation withstands 750 v ac rms 60 cps. At max recommended speed of 5000 rpm, engagement time is 4 millisec. Power consumption is 3.5 w. **Guidance Controls Corp, 110 Duffy Ave, Hicksville, NY.**

Circle 322, Reader Service Card

Thermistors are stabilized . . .

by process, developed in Belgium, incorporating exposure to high-frequency sound waves. Panel-type thermistor-principle temperature thermometers, with switch boxes and small threaded probes for permanent mounting to other equipment, are available with any length lead, which can be brought through switches or slip rings without recalibration. Standard accuracies are up to 0.14 C or 0.25 F. Bead thermistors with 0.012 in. dia are said to obtain response times of less than 1 sec in liquids and 2.2 sec on surfaces. Readings are said to be completely reproducible. Various instruments cover temperatures from −328 to 845 F. Readability is ½° on greater temperature spans; up to 0.05° on shorter spans. Operate on standard ac voltage lines. Over 100 designs are available, lengths up to 5 ft, 3 in. Mounted in glass or stainless, with tips bent or forked. **Atkins Technical Inc, 1276 W 3rd St, Cleveland 13.**

Circle 323, Reader Service Card

Laboratory stop clocks . . .

for bench use are offered in standard (pictured) and deluxe models. Sloping-front instruments, about 4½ in. sq, have color-coded run and reset pushbuttons on case top. External-run socket on front panel permits remote manual or automatic running of clock. Timed outlet, also on panel front, is energized whenever clock is timing and permits controlling and timing of external loads. Deluxe model has side socket for remote, manual or automatic control with suitable control

(Continued on page 102)

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
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5. FORGED SOLID STEEL HEADS throughout entire line.
6. PILOTED PACKING GLAND with extra long bearing for additional strength and support to piston rod.
7. NO TIE-RODS TO STRETCH—gives you 360° port rotation . . . less space used . . . full strength.
8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

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T-J Spacemaker

for longer, more efficient cylinder service

You too—can reduce replacement expenditures—lower maintenance costs with the T-J Spacemaker cylinder line. Designed and engineered for ruggedness, and accuracy of operation, the Spacemaker assures longer, uninterrupted operation.

The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

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DAVID BROWN

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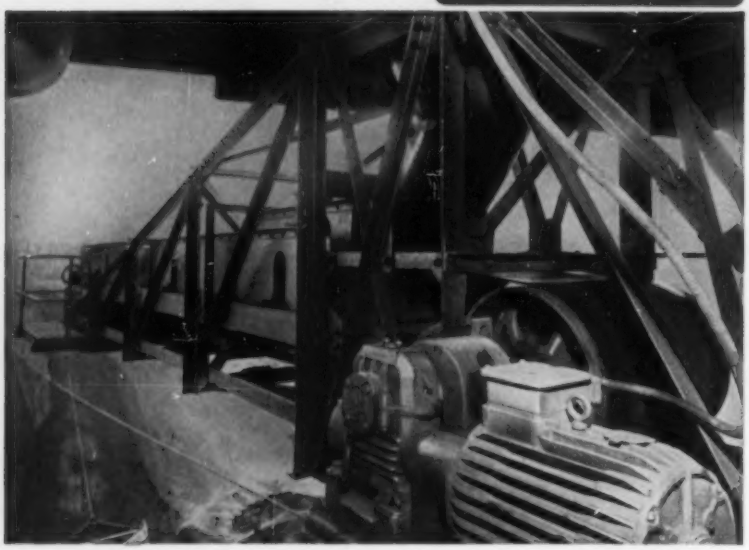

Radicons drive coal feed conveyors at one of England's largest power plants

WHY O.E.M. INSTALLATIONS ACCOUNT FOR 85% OF RADICON SALES

In Europe, Africa, South America, Australia, Canada and the U. S., Radicon speed reducers are harnessing motor speeds into working power for all industry.

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1. PRICE—The original equipment manufacturer is always fully protected on the industry's accepted discount, *and* Radicon drives are still competitively priced at the user level.

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4. DELIVERY—Off-the-shelf on Radicons in 14 sizes, 1⅛" to 14", 8 types, 17 ratios from 5:1 to 250:1.

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(one of the David Brown Industries)
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6025 Atlantic Blvd., Maywood, California
1224 S.W. Morrison St., Portland, Oregon

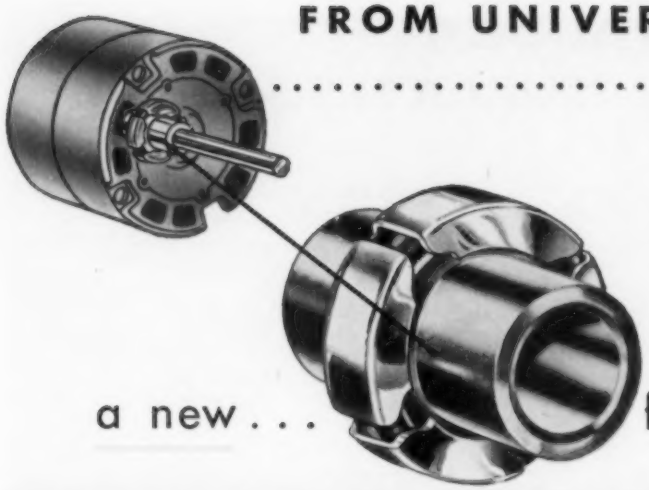
cable. Features include 6-ft line cord, 6-ft optional control cables, high-legibility angled dial, sweep second hand (calibrated in 10 millisec increments), clutchless timing system that does not require warmup time or standby power, rapid electrical reset (2 sec max) and low power drain (2 w timing). Standard model allows 2-station run, 1-station reset; deluxe model permits 3-station run, 2-station reset. Operates on 105 to 125 v, 57 to 63 cps; 2 w nominal run, 10 w max, reset. Operating temperature range is 50 to 110 F. Life is said to be 1000 hr or 50,000 operations. **A W Haydon Co, Waterbury, Conn.**

Circle 324, Reader Service Card

All-angle drafting machine . . . is for use on any board, without adjustment. Enclosed counterweight unit counterbalances at all board angles from horizontal to vertical. Reinforced U-beam construction assembles components within channel, protecting them from accidental damage or exposure to dust and dirt. Major moving parts are equipped with nylon wheels that ride on rigid, hidden tracks. Protractor head responds to index-finger touch-control for angle selection. When control is depressed, scales rotate to desired position and lock into place. Can be raised to any height off board without disturbing settings. Installs by two corner braces that fit over top board corners and are screwed on. Available to fit all standard board sizes, as well as others on special order. **Charles Bruning Co, 1800 W Central Rd, Mt Prospect, Ill.**

Circle 325, Reader Service Card

FROM UNIVERSAL ELECTRIC



THE UNIVERSAL BEARING*

a new . . . free aligning bearing

*PATENT APPLIED FOR

A new revolutionary bearing assembly, the **Universal Bearing,** that promises to eliminate fractional hp motor bearing problems has been designed and is now a feature of UNIVERSAL ELECTRIC motors. The new **Universal Bearing** does not rely on spring tension to aid its alignment but utilizes only the shaft itself. This is accomplished by moving the axis of support from the end of the bearing to the center . . . the ideal location.

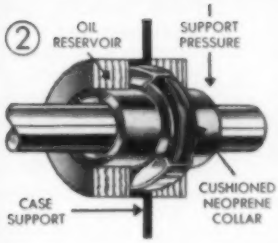
Flexibility and rigidity of bearing support and bearing are of primary importance, particularly in fractional hp motors. The design of the **Universal Bearing** insures continuous and positive alignment to the shaft at all times. A neoprene collar, which is flexible, provides a perfect and firm fit between bearing and bearing support surface. The **Universal Bearing** is inherently in balance . . . and cannot get out of either alignment or balance. It is as firm as a rigid bearing; more flexible than a self aligning bearing.

The **Universal Bearing** Assembly provides longer bearing life, better lubrication and an easier starting motor that runs without a whisper of sound. This is the first major bearing improvement since UNIVERSAL introduced the coil spring bearing retainer in 1944.

TYPE 23
1/50 to 1/12 H.P.

These are the first two UNIVERSAL ELECTRIC motors to feature the revolutionary, new **Universal Bearing.**

TYPE 118
1/200 to 1/50 H.P.



The new **Universal Bearing** is so designed that support pressure is on the center of the bearing, rather than on the end. This eliminates the uneven tension common in the spring and permits adjustment of the axis position to *true* alignment. The bearing is inherently in balance and can adjust to any shaft misalignment 100% of the time under any load conditions. A neoprene collar is used around the outside surface of the bearing to accommodate manufacturing tolerances. Small metal clips are fitted around the outside surface to confine the neoprene collar and allow a free sliding movement along the bearing support surface. The neoprene collar expands or contracts within the metal clips to afford a perfect mating surface.

50-A

UNIVERSAL ELECTRIC COMPANY

PRECISION ELECTRIC MOTORS

EXECUTIVE AND GENERAL SALES OFFICES: OWOSSO, MICHIGAN, DEPT. 12

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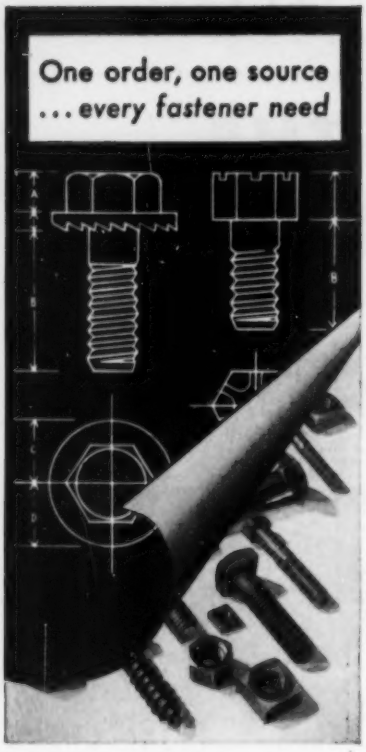

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CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 113.

CORROSION GUIDE FOR FASTENERS—Booklet, 24 pp. Most commonly used metals are tabulated to show approximate physical and mechanical properties and suitability for manufacturing applications. Cross index for chemically-equivalent specifications cross-references metals to ASTM specs, MIL specs and Federal specs. H M Harper Co, 8200 Lehigh Ave, Morton Grove, Ill.

Circle 331, Reader Service Card

DESIGNING WITH LAMINATED PLASTICS—Manual, 206 pp. More than 50 grades are included. Contains comparator chart itemizing qualities of most popular grades, a listing of materials by military spec number and design information on all standard and special grades. Primary function is shown and other uses are suggested. Formica Corp, 4614 Spring Grove Ave, Cincinnati 32.

Circle 332, Reader Service Card

COLD-DRAWN STAINLESS STEEL—Book, 77 pp. Describes general qualities of 27 types of ferritic, austenitic, ferritic-austenitic and martensitic stainless steels. Data is also included on tolerances, mechanical properties, magnetic properties, finishes, sizes, forms and applications for cold-drawn steel. Uddeholm Co of America, 155 E 44th St, New York 17.

Circle 333, Reader Service Card

PRESSURE SWITCHES—Handbook and catalog PS-59-60, 36 pp. Contains information on electrical and operating characteristics, ordering chart, adjustment instructions, spare parts table, parts blowup and dimensional diagram. Also includes such information as glossary of terms, switch selection chart, electrical rating tables and functional schematic symbols. Barksdale Valves, 5125 Alcoa Ave, Los Angeles 58.

Circle 334, Reader Service Card

SPROCKETS AND ROLLER CHAINS—Catalog 60, 88 pp. Covers specifications and ratings of 1300 different stock sprockets and various types of roller chains, as well as design and engineering information for chain drives. Cullman Wheel Co, 1344 Altgeld St, Chicago 14.

Circle 335, Reader Service Card

FINISHES FOR ALUMINUM—Handbook, 24 pp. Presents information on preparation and treatment of aluminum surfaces to permit selection of best finish for a particular application. Starting with cleaning, booklet explains theory and method for five major types of finishing operations, including advantages, disadvantages and costs. Reynolds Metals Co, Dept PRD-9, Box 2346, Richmond 18, Va.

Circle 336, Reader Service Card

ALUMINUM FINISHING—Manual, 16 pp. Discusses problems concerning finishing of aluminum, as well as methods and materials for their solution. Frederick Gumm Chemical Co Inc, 538 Forest St, Kearny, NJ.

Circle 337, Reader Service Card

ALUMINUM HAND FORGINGS—Brochure, 16 pp. Lists availabilities, properties and performance characteristics of aluminum hand forgings, which can be supplied in any size, any desired temper and in variety of shapes for specific parts. Kaiser Aluminum & Chemical Sales Inc, Dept NR-32, 1924 Broadway, Oakland, Calif.

Circle 338, Reader Service Card

PRECISION SWITCHES—Catalog 359, 24 pp. Information on expanded line of snap-acting precision switches. Pictorial index shows where to find dimensional drawings, descriptions, force and movement spec tables and electrical ratings for each switch listed. Unimax Switch Div, W L Maxson Corp, Ives Rd, Wallingford, Conn.

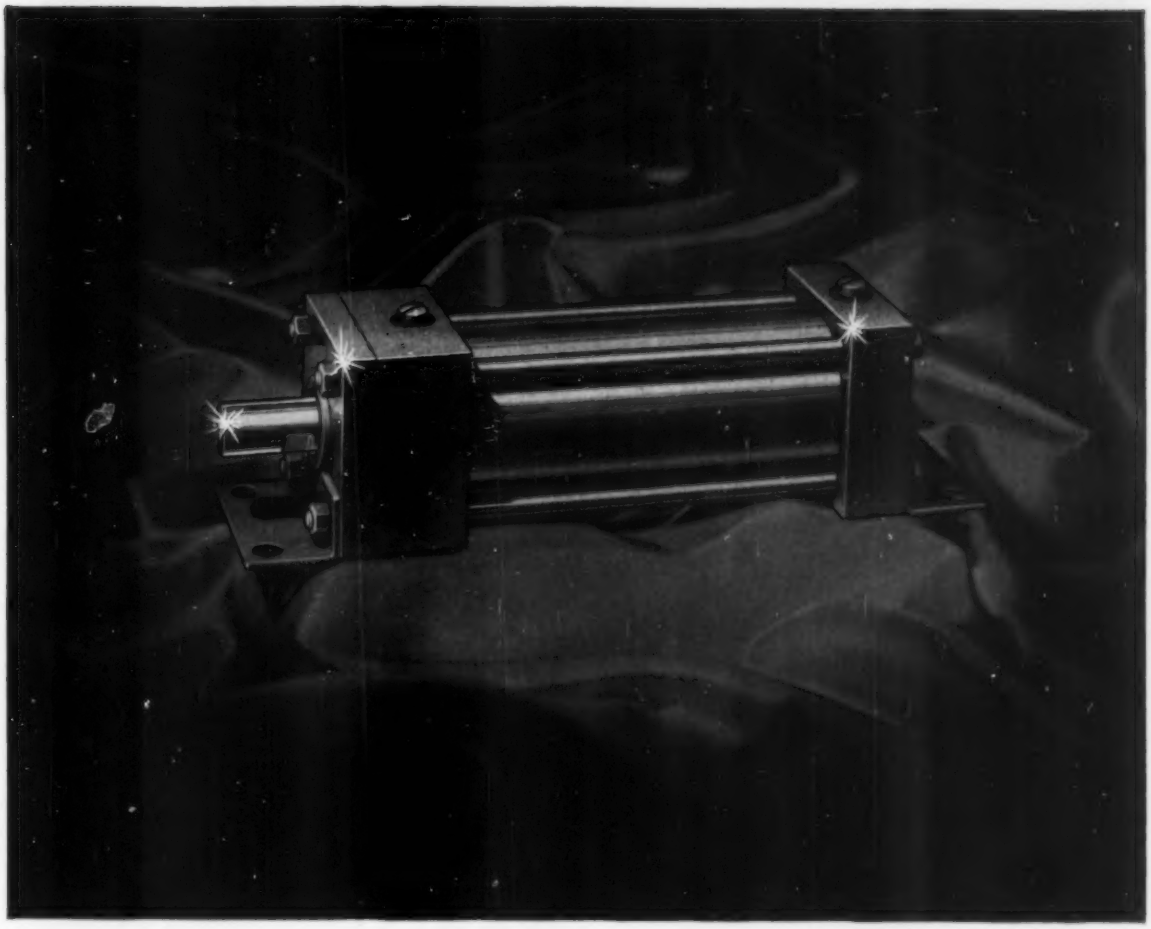
Circle 339, Reader Service Card

MEASURING AND RECORDING INSTRUMENTS—General catalog 1310, 16 pp. Describes entire line of dynamic-measuring and recording instruments. Includes summary of specifications for this company's standard galvanometers. Consolidated Electrodynamics Corp, 360 Sierra Madre Villa, Pasadena, Calif.

Circle 340, Reader Service Card

INDUSTRIAL AND ELECTRONIC COILS—Catalog 60, 44 pp. Specifications and pricing information on 1300 standard TV, radio and transistor coils and an expanded listing of industrial coils and chokes. Contains separate part-number index and price list, cross-reference of

(Continued on page 107)



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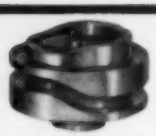

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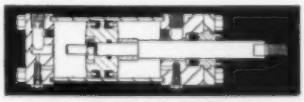

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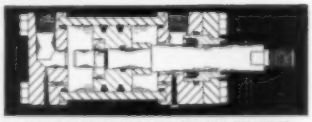

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original parts to Miller equivalents, and 117 IF-RF schematic diagrams. J W Miller Co, 5917 S Main St, Los Angeles 3.

Circle 341, Reader Service Card

HYDRAULIC PACKINGS – Bulletin P-333, 16 pp. Specifications and design data on fabric-reinforced and homogeneous V-rings, U-cup packings and piston cup packings. Encompasses design, construction, sizes, applications, installation and proper usage. Crane Packing Co, Dept PR-1, 6400 Oakton St, Morton Grove, Ill.

Circle 342, Reader Service Card

ELEVATED-TEMPERATURE MAGNESIUM ALLOYS–Bulletin 141-204, 30 pp. Describes recommended practices for working magnesium alloys of thorium and rare-earth metal families. Covers machining, forming, joining, assembly protection and finishing. Tables list tool temperatures, bend radii and welding information. Dow Chemical Co, Midland, Mich.

Circle 343, Reader Service Card

RADIAL - PISTON HYDRAULIC PUMPS–Brochures, 4 pp each. Bulletins cover 18 and 50 gpm models. Each includes performance curves, ratings, design features, dimensional and installation diagrams. Texas Hydraulics Inc, 8500 Research Blvd, Austin, Tex.

Circle 344, Reader Service Card

NUTS AND FASTENERS–General Catalog, 16 pp. Describes line of standard and special clinch, pilot and weld nuts. Specifications, application information, and reference tables for recommended nut torque and pertinent screw thread data are given. McLaughlin Co, 212 Jaikins Blvd, Birmingham, Mich.

Circle 345, Reader Service Card

WIRE CLOTH PRODUCTS–Catalog, 24 pp. Tables list wire and mesh sizes normally in stock in various metals, types of weaves. Wire Cloth Products Inc, 2801 Congress St Expressway, Bellwood, Ill.

Circle 346, Reader Service Card

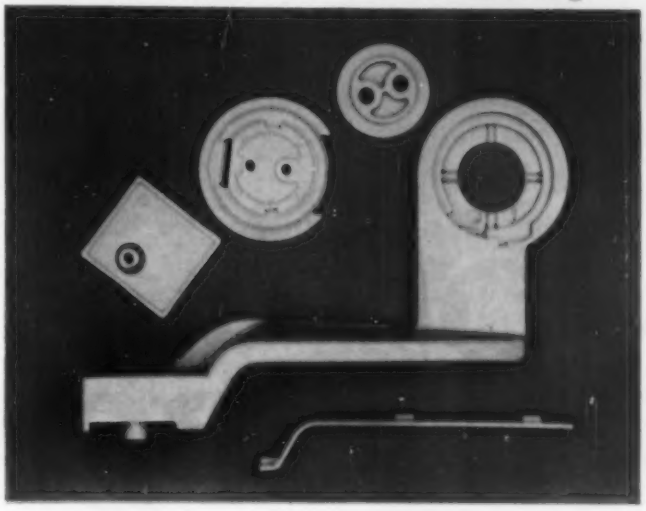
LOW-PRESSURE FORMING OF THERMOPLASTIC SHEET – Manual, 48 pp. Covers such subjects as materials, storage, cutting and layout, heating, molds or formers, forming methods, machining and trimming, design, cost and economics, case histories and technical assistance in 15 chapters. Appendix lists material suppliers. General Tire & Rubber Co, Bolta Products Div, 70 Garden St, Lawrence, Mass.

Circle 347, Reader Service Card

CAM-OPERATED INDEXING UNIT –Bulletin ST-A9A, 20 pp. Basic indexing

(Continued on page 109)

POLAROID specified dimensional accuracy

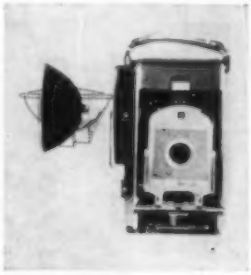


and got it from CONSOLIDATED

Both dimensional accuracy and fine appearance were essential requirements in the production of this camera flash attachment for Polaroid. Naturally, mold planning and construction were of utmost importance in such a critical job. Precision and timing had to be built into the mold design. Three different molds were necessary to produce the five separate pieces which form one synchronized unit.

In assembling the unit, all parts had to be kept in perfect alignment; no warpage or twist was permitted. For appearance's sake, it was necessary to locate mold parting lines on the natural edges of the pieces.

This flash attachment unit represents the type of molding challenge Consolidated welcomes. We appreciate the opportunity to quote on any molding – complicated or simple.



The Polaroid Bounce Flash Bracket (Model #292), with swivel-type flash gun clip, permits the taking of both horizontal and vertical pictures without removing the gun to change its position.

For more than 80 years we have been filling exacting plastics orders for the nation's blue chip companies. Before you discard any design you feel can't be molded in a plastic, call Consolidated.

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. . . the lightweight, inexpensive replacement for cost-heavy metal tote boxes . . . hold big loads without bending or twisting . . . easy to lift with wide roll-over edges . . . cross stack securely or nest conveniently when not in use . . . will not shatter under heavy impact . . . resist steam cleaning or freezing temperatures . . . withstand oils, greases, acids, chemicals, strong detergents. Size: 21" x 15½", inside depth, 5½". Color: Coffee brown.

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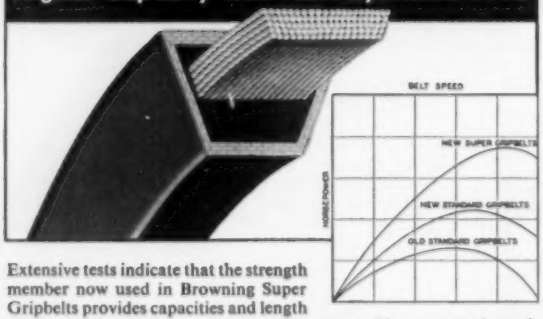
Browning SUPER GRIPBELTS

Higher Capacity with New Synthetic Cord



Extensive tests indicate that the strength member now used in Browning Super Gripbelts provides capacities and length stability far beyond those of any previous vegetable or synthetic cord. With other advances in materials and design, this high strength cord improves performance and obsoletes former ratings. Advantages:

- Capacities up to 2¼ times previous standard Gripbelts
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- Lower costs for both original equipment and maintenance
- Standard size sheaves and belts cover full hp range
- Available NOW from distributor stocks, coast to coast

Browning *Standard* Gripbelts have been increased in similar proportion, to today's realistic ratings as indicated in the chart. For information on both Standard and Super Gripbelts, ask your Browning distributor. Or write **Browning Manufacturing Company, Maysville, Kentucky.**

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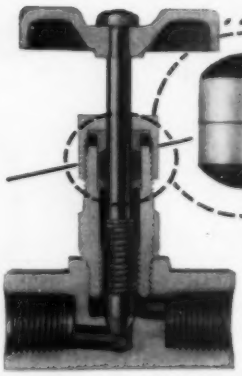
"...yet we have IMPROVED it"

The Marsh Stainless Steel Needle Valve could have gone right on being the finest in its field...yet we have improved it



...with fabulous **"TEFLON"** *packing*

Note the "close-up." The Marsh Marpak packing system, originated in the Marsh Needle Valve, was one of the factors that has enabled it to stand up and work right under pressures up to 10,000 psi.

Now "Teflon" is used in this packing system—the miracle material of almost incredible *toughness, resilience* and *non-adhesive* properties...properties that are not impaired by the most powerful of solvents, acids, or alkalies even at temperatures *up to 500° F.*

Net result: The guaranteed application-range (up to 10,000 psi) is now effective at any temperature up to 500° F. (In other makes, permissible temperature decreases as pressure increases.)

Marsh Marpak Teflon Packing System is standard in Marsh 416 Stainless Steel Needle Throttling Valves. Ask for facts.

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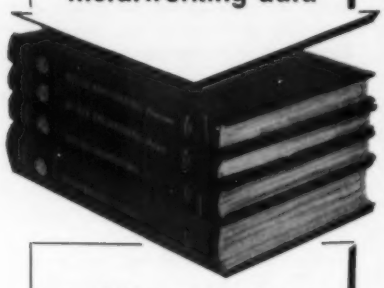
ASME presents your complete source of metalworking data



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and locking units in three styles are described through schematics. Tables outlining available motors and timers for standard and special drives and load rating tables are also included. Standard Tool and Mfg Co, 237 Laurel Ave, Kearny, NJ.

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ELECTROMAGNETIC PULLEY—Bulletin 1011, 8 pp. Explains application of magnetic pulleys and outlines principle of operation. Describes new series available. Tables and formulas are included for selection of proper pulley size. Includes table of approximate weights per cu ft of 146 materials that are often handled on belt conveyors and a list of industries where magnetic separation has proved beneficial. Stearns Magnetic Products, 635 S 28th St, Milwaukee 46.

Circle 349, Reader Service Card

ENVIRONMENTAL TEST CHAMBERS—Catalog 59, 12 pp. General specifications and illustrated descriptions of environmental test equipment. American Research Corp, Farmington, Conn.

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MARKING DEVICES—Catalog MA-59, 24 pp. Automatic roll marker and manual marking devices for most product marking and identifying requirements are pictured. Includes specifications and descriptions of various models. New Method Steel Stamps Inc, 147 Jos Campau, Detroit 7.

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WELDED STEEL TUBING—Brochure, 12 pp. Covers carbon and stainless steel tubing composition, test results, advantages, size ranges available, welding, fabrication and standard joining methods. Formed Steel Tube Institute, 850 Hanna Bldg, Cleveland 15.

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SPECIAL WIRE FORMS—Brochure 102, 8 pp. Condensed guide book on special wire forming and metal stamping. Illustrated instructions and diagrams to help in specification of special forms. Includes wire gage chart. Merrill Mfg Corp, Merrill, Wis.

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SPRAYED-ON HEATING ELEMENT—Catalog HB-3-359, 12 pp. Describes physical, electrical, thermal characteristics of film-type, sprayed-on heating element. Contains charts and graphs on protective coatings and insulation, temperature rise vs time and standard terminals available. Electrofilm Inc, PO Box 106, N Hollywood, Calif.

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LUBRICANT-SELECTOR CHART—Bulletin 121, 4 pp. Evaluates every lubri-

(Continued on page 150)

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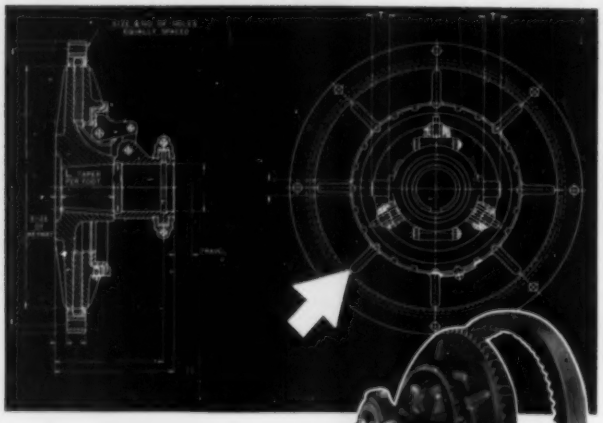

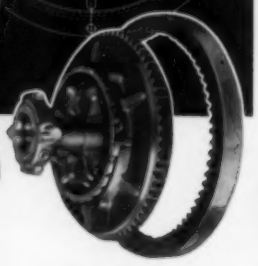

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cant in company's line based on temperature, environment, method of application, incorporation into common materials and makes recommendations for various parts, operations and conditions. Alpha-Molykote Corp, 65 Harvard Ave, Stamford, Conn.

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ELECTRIC PROCESS HEATERS—Catalog 60, 64 pp. Illustrates and describes line of heaters (with lists of types, sizes and ratings) and their various uses. Application section includes information on how to determine required capacity, how to calculate kw capacity to maintain operating temperature and how to select proper heater type. Edwin L. Wiegand Co, 7500 Thomas Blvd, Pittsburgh 8.

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CLUTCH-PULLEY PACKAGE – Brochure, 8 pp. Design features, performance information, dimensions and selection charts on electric clutch package for use with motors of 1 to 25 hp. Warner Electric Brake & Clutch Co, Beloit, Wis.

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HYDRAULIC PRODUCTS – Catalog, about 55 specification sheets in binder. Each sheet contains general specifications, performance charts, dimensional diagrams and construction information. Indexed into sections on gear pumps, hydraulic cylinders, control valves, hydraulic hose. Industrial Products Div, Cessna Aircraft Co, Hutchinson, Kans.

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INDUSTRIAL COATED FABRICS—Bulletin, 8 pp. Gives characteristics and specifications of about 96 items in line of natural and synthetic rubber-coated fabrics. Vulcan Rubber Products Div, Reeves Bros Inc, 1071 Ave of the Americas, New York 18.

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PNEUMATIC COUPLINGS AND FITTINGS—Brochure, 8 pp. Sizes, dimensions, applications, performance curve on assorted types of sockets, plugs and similar parts. Hofmann Engineering Co, 4022 W 55th St, Chicago 32.

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PREALLOYED METAL POWDERS—Brochure, 8 pp. Explains meaning of word "prealloyed" and lists types of prealloyed metal powders produced by company. Typical properties of sintered steel powders are shown, along with photos of parts. Powder Metallurgy Dept, Vanadium Alloys Steel Co, Latrobe, Penna.

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POWDERED-METAL PROCESS—Booklet, 16 pp. Contain description of com-

(Continued on page 113)

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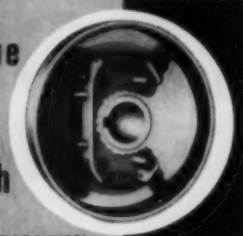

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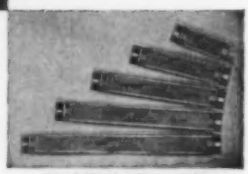

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pacting process, design details that are preferred and those to be avoided. Also has chart of physical characteristics. Reese Metal Products Corp, Lancaster, Penna.
Circle 362, Reader Service Card

POWER-TRANSMISSION MACHINERY–Bulletin A-706, 8 pp. Digest of descriptions, specifications and performance of power-transmission products. Dodge Mfg Corp, Mishawaka, Ind.
Circle 363, Reader Service Card

Letterhead Requests Only

Manufacturers who publish following literature ask that requests for copies be made on company letterheads.

TABLES AND FORMULAS–Booklet B-3677D, 120 pp. Contains convenient tables, formulas, graphical symbols summarizing electrical data, properties of materials, heat transfer and steam information, measurements and similar subjects. Westinghouse Electric Corp, Box 2099, Pittburgh 30.

OIL BYPASS RELIEF VALVES–Mechanical data book, 16 pp. Contains valve description, ordering, installation and maintenance information, plus specifications and ratings. Standard brass, cast iron and all-steel valves are covered. Fulflo Specialties Co Inc, 440 Fancy St, Blanchester, Ohio.

ELECTRICAL SWITCHES AND ACTUATORS–Reference catalog ES-59, 52 pp, bound. Volume contains photos, dimensional drawings, specifications and modification information on electrical switches and actuators. Discusses switch terminology, basic design types, operating methods and environment application data. Electrosnap Corp, Switch Div, 4218 W Lake St, Chicago 24.

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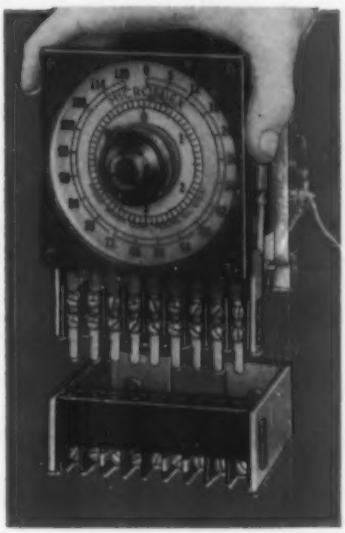

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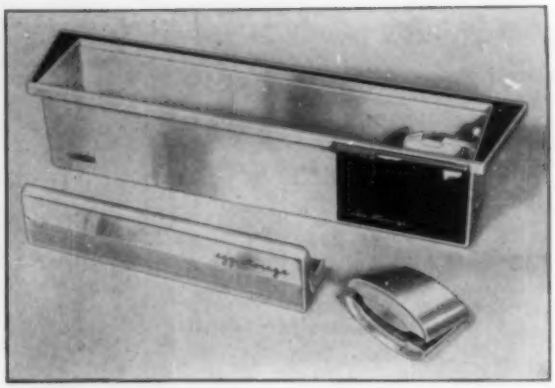

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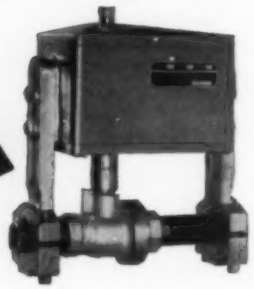

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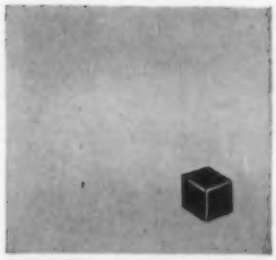
(Continued on page 116)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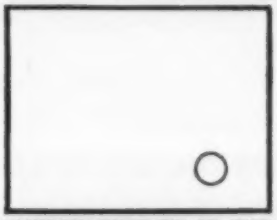
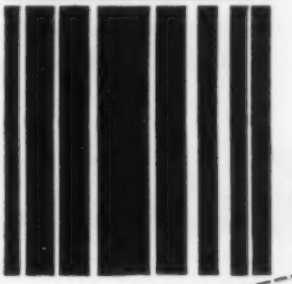
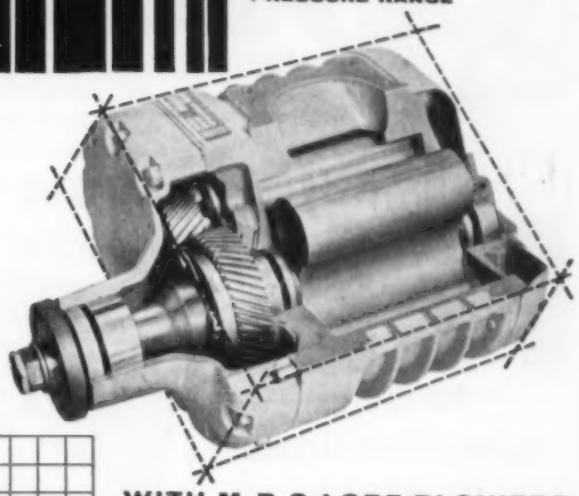
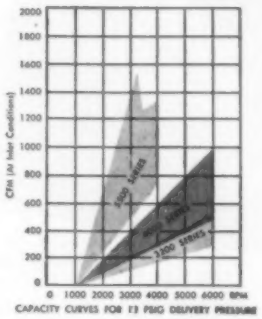

LIGHTEST WEIGHT


WIDEST PRESSURE RANGE





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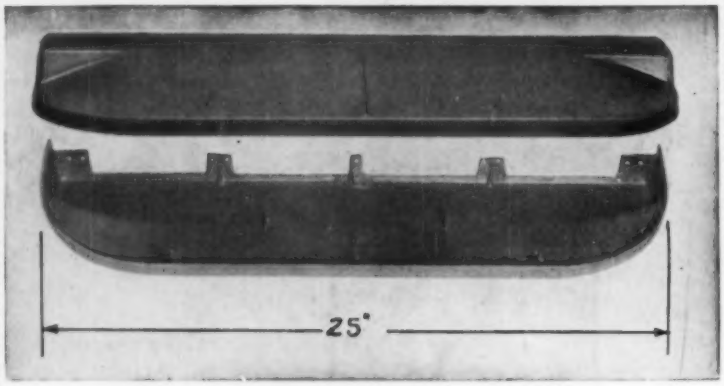

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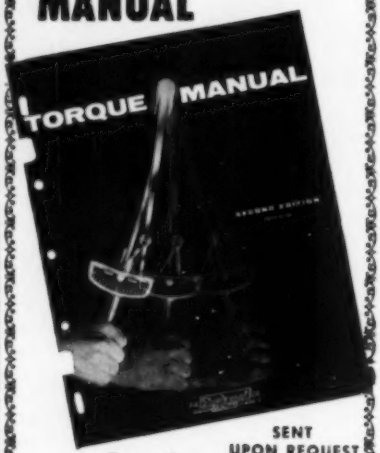

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Factors to be considered in evaluating finishes for springs are discussed and testing procedures are described. Properties and characteristics of metallic, organic and other types of coatings are included in a two-page table.

"Evaluation of Finishes for Springs," The Mainspring, April-May 1959, Associated Spring Corp, Bristol, Conn.

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Five of the papers discussing theory, design and application of systems and devices for governing internal combustion engines presented at the SAE (485 Lexington Ave, New York 17) are numbered 8OT through 8OZ.

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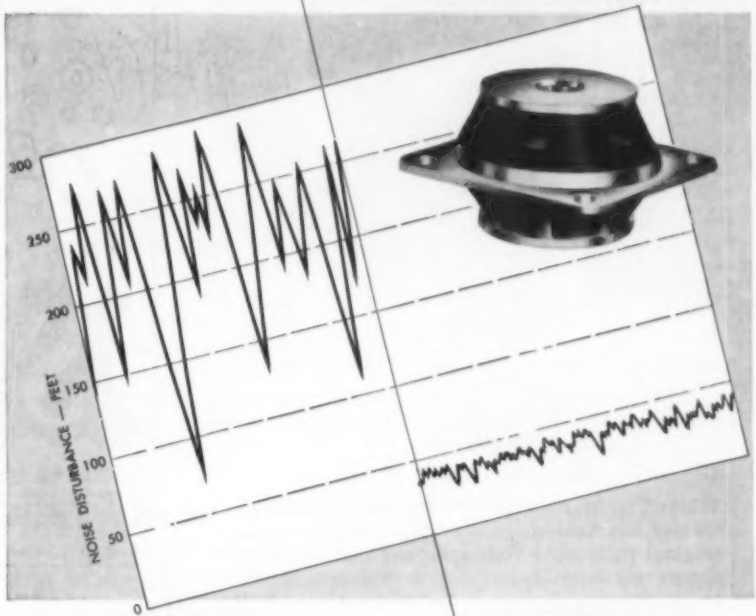

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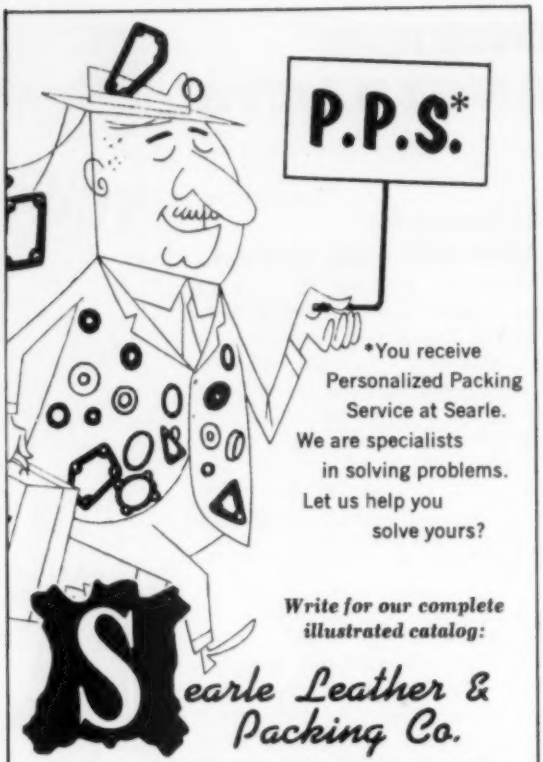

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NEW BOOKS

Physical Anthropology in Human Engineering

PB 151447. HANSEN AND CORNOG. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 64 pp, $2.

This bibliography contains condensations of 121 reports in the field of applied physical anthropology. A majority of the annotations are grouped under three headings, anthropometry, biomechanics, and comfort; a few are included in a general group. Working data and important illustrations are quoted directly from the original papers in most cases. A complete index is arranged by author as well as by subject. An additional list of reports (not annotated) is included as background material. Two appendices containing relevant commentary on seating comfort and anthropometric dummies, are also included.

Man's Senses as Information Channels

PB 151160. MOWBRAY AND GEBHARD. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 64 pp, $2.

This review attempts to survey in a general fashion what is known about man's ability to make use of his sensory capacities for the gathering of information. Where possible, comparisons between different sense modalities are made and the problem of sensory interactions is discussed. Finally, some suggestions are offered relative to the possible unburdening of men in complex environments by the judicious use of some of the subordinate sensory channels.

Dynamic Response of Human Operators

PB 131823. McRUER AND KRENDEL. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 248 pp, $4.

This report presents the results of concerted efforts to arrive at a suitable mathematical description of human operator dynamic response. The investigation has been primarily concerned with operations in which continuous closed-loop control is exerted in a visual input, manual output track-

(Continued on page 121)

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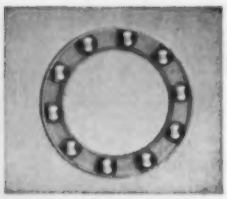

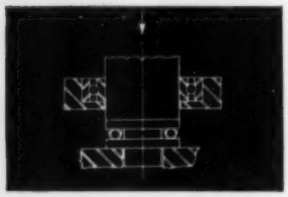
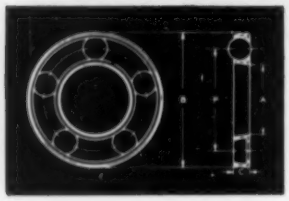
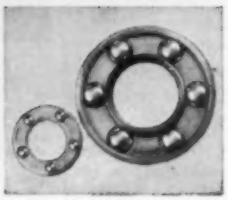

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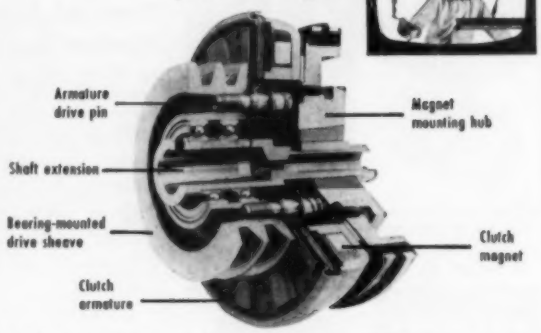

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ing situation subjected to excitation by random appearing forcing functions.

The material on which the study was based was a relatively large body of data on human response characteristics, some available from earlier investigators and some from concurrent experiments. All of the data available, published or unpublished, were considered in arriving at the various descriptions of interest. A portion of the report is devoted to an exposition of the mathematical basis for the models derived and measurements taken.

Applied Mathematics for Engineers and Scientists

C G LAMBE. The Macmillan Co, 60 Fifth Ave, New York 11. 6 x 9, 518 pp. $8.50.

This book, written by a professor of mathematics at the Royal Military College of Science in England, gives a thorough account of those parts of dynamics, statics, hydromechanics and wave motion that are of fundamental importance to engineers and scientists. A practical approach is maintained and there are more than 1000 worked examples and exercises. Chapters on dynamics deal with the motion of a particle, the plane motion of a rigid body, vector analysis and Lagrange's equations. There is also an account of Fourier series, harmonic analysis and small oscillations, including the vibrations of beams. There are three chapters on statics, namely, statics of a rigid body, statics of strings and chains and structural statics, which includes the theory of bending moments, deflexions and struts.

(Continued on page 122)

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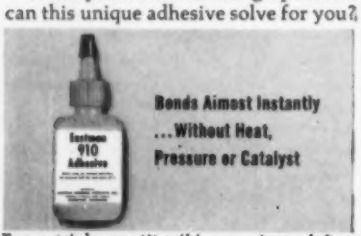

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Handbook of Practical Electroplating

THOMAS M RODGERS. Macmillan Co, 60 Fifth Ave, New York 11. 5 x 7¾, 333 pp, $8.50.

This book covers, in encyclopedic form, the actual practices of plating shops as well as background on the theory of plating. It has been written for the man on the job, for the supervisor responsible for managing an electroplating process, and for the engineer whose training has been in another field.

Included are the formulas for all the basic plating baths, sections on the installation and maintenance of equipment, on salt-water gilding and on immersion plating. Special emphasis is given to the problems of achieving various decorative colors by electroplating processes.

Each type of plating is described in terms of its industrial uses, equipment, solution composition, operation, maintenance and analytical control of solution.

Legibility of Reflex-reflective Numerals

PB 151480. CRANNELL AND DEBONS. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 21 pp, 75¢.

The legibility of AND 10400 digits under nighttime conditions was investigated, using four different sets of all ten digits: black digits on aluminum background, black digits on white painted background, black digits on reflex-reflective background, and reflex-reflective digits on black background.

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sight; and (3) at a distance of 500 ft when the level of illumination was increased by moving the spotter lamp closer to the display. Under nighttime conditions reflex-reflective digits are more legible than the other display conditions at the greater distances, and at the closer distances when the digits are tilted or turned from the perpendicular to the line of sight.

Other Books of Interest

Human Engineering—Catalog of Technical Reports.
Office of Technical Services, Dept of Commerce, Washington 25, DC. 7¾ x 10¼. 7 parts, 10¢ each.

Human Tolerance to Some Accelerations Anticipated in Space Flight.
PB 131821. Bondurant, Clarke, Blanchard, Miller, Hessberg and Hiatt. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 17 pp. 50¢.

Effect of Water Immersion on Human Tolerance to Forward and Backward Acceleration.
PB 151315. Bondurant, Blanchard, Clarke and Moore. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 12 pp. 50¢.

Research on Ferrous Materials Fatigue.
PB 151243. Cummings, Stulen and Schulte. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 104 pp. $2.50.

Effect of Static Prestrain on Fatigue Properties of Unnotched and Notched Materials at Room and Elevated Temperatures.
PB 151280. F H Vitovec. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 60 pp. $1.75.

Proposed Mechanism for the Strengthening of Sintered Aluminum Powder-type Alloys.
PB 151047. G S Ansell. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 5 pp. 50¢.

Selection and Evaluation of Rare or Unusual Metals for Application to Advanced Weapons Systems, Part I: A Literature Survey.
PB 151311. B Love. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8½ x 11, 174 pp. $3.

Study of Ultrahigh Temperatures.
PB 131732. A V Grosse, A G Streng. Office of Technical Services, Dept of Commerce, Washington 25, DC. 8 x 10½, 98 pp. $2.50.

Scientific Management of Marketing Operations.
A N Seares. Society of Advancement of Management, 74 Fifth Ave, New York 11. 5½ x 8½, 35 pp. $1.50.

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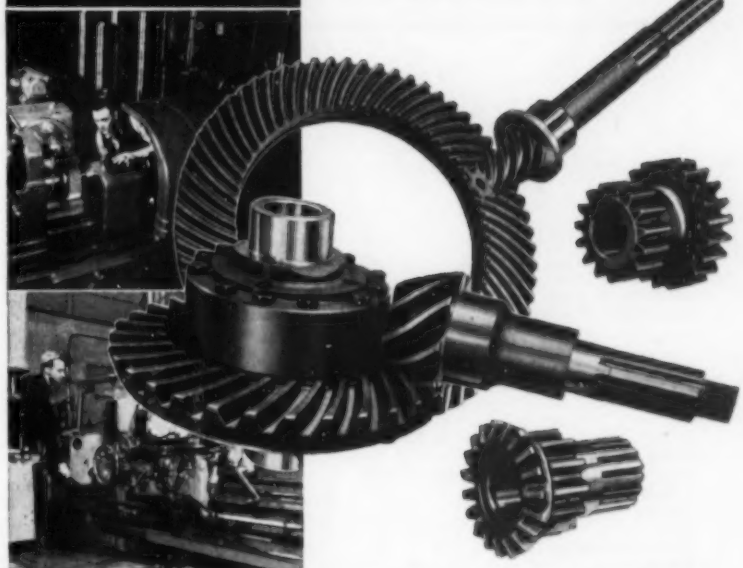

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CIRCLE NO. 123 READER SERVICE CARD 123

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CLASSIFIED ADVERTISING
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EMPLOYMENT OPPORTUNITIES 122

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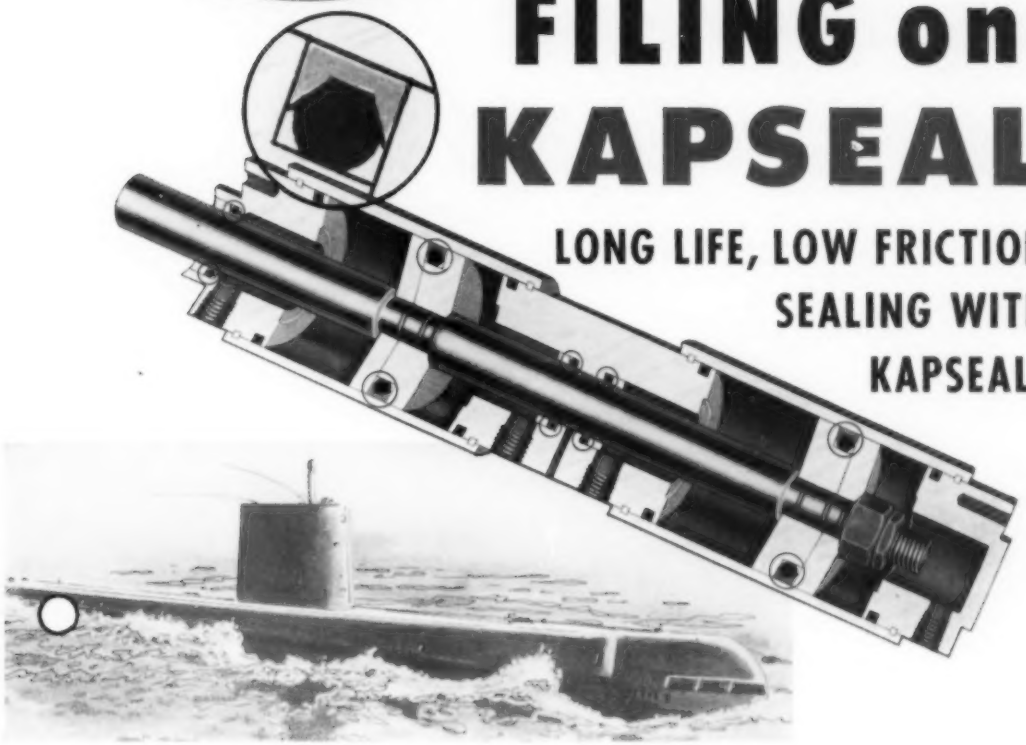
FACTS for FILING on KAPSEAL®

LONG LIFE, LOW FRICTION SEALING WITH KAPSEAL!



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COMBINES WITH A STANDARD O-RING

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FOR MORE INFORMATION ON THE KAPSEAL . . .

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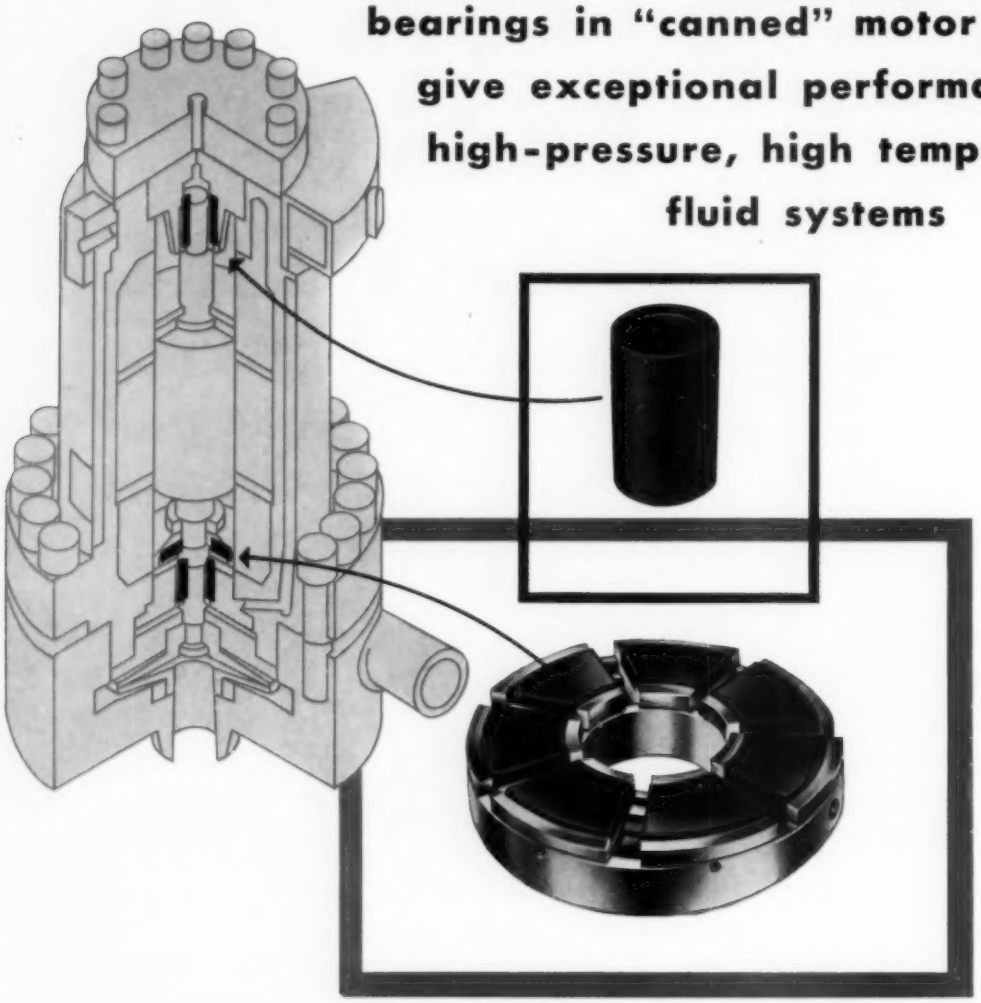

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